KEITHLEY

Model 175
Instruction Manual

Contains Operating and Servicing Information for the Model 175 Autoranging Multimeter and 1758 Rechargeable Battery Pack

Publication Date: April 1984
Document Number: 175-901-01C

WARRANTY

Keithley Instruments, Inc. warrants this product to be free from defects in material and workmanship for a period of 1 year from date of shipment. During the warranty period, we will, at our option, either repair or replace any product that proves to be defective.

To exercise this warranty, write or call your local Keithley representative, or contact Keithley headquarters in Cleveland, Ohio. You will be given prompt assistance and return instructions. Send the instrument, transportation prepaid, to the indicated service facility. Repairs will be made and the instrument returned, transportation prepaid. Repaired products are warranted for the balance of the original warranty period, or at least 90 days.

LIMITATION OF WARRANTY

This warranty does not apply to defects resulting from unauthorized modification or misuse of any product or part. This warranty also does not apply to fuses, batteries, or damage from battery leakage.

This warranty is in lieu of all other warranties, expressed or implied, including any implied warranty of merchantability or fitness for a particular use. Keithley Instruments, Inc. shall not be liable for any indirect, special or consequential damages.

STATEMENT OF CALIBRATION

This instrument has been inspected and tested in accordance with specifications published by Keithley Instruments, Inc.

The accuracy and calibration of this instrument are traceable to the National Bureau of Standards through equipment which is calibrated at planned intervals by comparison to certified standards maintained in the Laboratories of Keithley Instruments, Inc.

KEITHLEY

KEITHLEY INSTRUMENTS, INC.

INSTRUMENT DIVISION / 28775 Aurora Road / Cleveland, Ohio 44139 / U.S.A. / (216) 248-0400 / Telex: 98-5469
WEST GERMANY: Keithley Instruments GmbH / Heiglhofstr. 5 / 8000 München 70 / (089) 710020 / Telex: 52-12160
GREAT BRITAIN: Keithley Instruments, Ltd. / 1, Boulton Road / Reading, Berkshire RG 2 ONL / (0734) 86-12-87/88 / Telex: 84-7047
FRANCE: Keithley Instruments SARL / 2, Bis Rue Léon Blum / B.P. 60 / 91121 Palaiseau Cedex / (6) 011-51-55 / Telex: 600-933
NETHERLANDS: Keithley Instruments BV / Arkelsedijk 4 / Postbus 559 / 4200 AN Gorinchem / (0) 1830-25577 / Telex: 24-684
SWITZERLAND: Keithley Instruments SA / Kriesbachstr. 4 / 8600 Dübendorf / 01/821-94-44 / Telex: 57-536
AUSTRIA: Keithley Instruments Ges.m.b.H. / Döblinger Haupstr. 32 / 1190 Wien / 314 289 / Telex: 13-4500
ITALY: Keithley Instruments, SRL / Viale S. Gimignano 4/A / 20100 Milano, Italy / 4120360

Instruction Manual
Model 175
Autoranging Multimeter

©1983, Keithley Instruments, Inc.
Cleveland, Ohio, U.S.A.
Document Number 175-901-01

SPECIFICATIONS

DC VOLTS

RANGE	RESOLUTION	ACCURACY (1 YEAR) 18°-28°C ±(%rdg+counts)
200mV	10 μV	0.03+2
2 V	100 μV	0.03+1
20 V	1mV	0.03+1
200 V	10mV	0.03+1
1000 V	100mV	0.03+1

INPUT RESISTANCE: 11MΩ on 200mV, 2V and 20V ranges. 10MΩ on 200V and 1000V ranges. (Greater than 1000MΩ on the 200mV and 2V ranges with all function buttons in the out position).

NORMAL MODE REJECTION RATIO: Greater than 60dB at 50Hz, 60Hz ± 0.15%.

MAXIMUM ALLOWABLE INPUT: 1000V DC or peak AC (less than 10 seconds per minute on the 200mV and 2V ranges; 300V rms continuous).

SETTLING TIME: 1 second to within 1 count of final reading on range.

dB MODE (ref: 600Ω):
Accuracy: ±(0.02dB+1 count) (above −78dBm).
Resolution: 0.01dB above 5% of range.

TRMS AC VOLTS

RANGE	ACCURACY (1 YEAR)* 18°-28°C ±(%rdg+counts) 20Hz-50Hz	50Hz-10kHz	10kHz-20kHz	20kHz-50kHz	50kHz-100kHz
2V - 750V	1+20	0.5+20	1 +40	2.5+75	5+200
200mV	1+20	0.5+20	1.5+40	8 +75	—

*Above 1800 counts.

MAXIMUM ALLOWABLE INPUT: 750V rms, 1000V peak (less than 10 seconds per minute on the 200mV range; 300V rms continuous). 10⁷V•Hz maximum.

3dB BANDWIDTH: 300kHz typical.

INPUT IMPEDANCE: 10MΩ paralleled by less than 75pF on 20V, 200V and 1000V ranges. 11MΩ on 200mV and 2V ranges. Capacitively coupled.

SETTLING TIME: 2 seconds to within 15 counts of final reading on range.

dB MODE (ref: 600Ω):

RANGE	INPUT	ACCURACY (±dBm) 20Hz-10kHz	10kHz-20kHz	20kHz-50kHz	50kHz-100kHz
2V-750V	200mV to 750 V (−12 to +59.8dBm)	0.2	0.26	0.56	1.2
200mV	20mV to 200mV (−32 to −12 dBm)	0.2	0.3	1	—
	2mV to 20mV (−52 to −32 dBm)	2	3	—	—
	1mV to 2mV (−58 to −52 dBm)	2*	—	—	—

*Up to 1kHz.

Resolution: 0.01dB above 5% of range.

OHMS

RANGE	RESOLUTION	ACCURACY (1 YEAR) 18°-28°C ±(%rdg+counts)	MAX. VOLTAGE ACROSS UNKNOWN ON RANGE
200 Ω	10mΩ	0.05+2**	0.2V
2 kΩ →|	100mΩ	0.05+1	2.0V
20 kΩ	1 Ω	0.05+2	0.2V
200 kΩ →|	10 Ω	0.05+1	2.0V
2MΩ } MΩ*	100 Ω	0.05+2	0.2V
20MΩ } MΩ*	1 kΩ	0.2 +1	2.0V
200MΩ } MΩ*	100 kΩ	2.0 +1	2.0V

*Appropriate range selected automatically. **With zero set by REL function.

MAXIMUM ALLOWABLE INPUT: 450V DC or peak AC.

OPEN-CIRCUIT VOLTAGE: +5V.

DIODE TEST: Display reads junction voltage up to 2V. Test current: 0.7mA nominal.

SETTLING TIME: 2 seconds to within 1 count of final reading on range.

DC AMPS

RANGE	RESOLUTION	MAXIMUM VOLTAGE BURDEN	ACCURACY (1 YEAR) 18°-28°C ±(%rdg+counts)
200 μA	10 nA	0.3V	0.15+2
2mA	100 nA	0.3V	0.15+2
20mA	1 μA	0.3V	0.15+2
200mA	10 μA	0.3V	0.2 +2
2000mA	100 μA	0.8V	0.2 +2
10 A	1mA	0.3V	0.75+2*

*Above 5A derate 0.15% rdg per amp for self-heating.

OVERLOAD PROTECTION: mA Input: 2A fuse (250V), externally accessible. 10A Input: 20A for 15s, unfused.

SETTLING TIME: 1 second to within 1 count of final reading.

TRMS AC AMPS

RANGE	MAXIMUM VOLTAGE BURDEN	ACCURACY (1 YEAR)* 18°-28°C ±(%rdg+counts) 20Hz-50Hz	50Hz-10kHz	10kHz-30kHz
200 μA -20mA	0.3V	1 +20	0.8+20	2+50
200mA	0.3V	1 +20	0.8+20	—
2000mA	0.8V	1 +20	0.8+20	—
10 A	0.3V	1.5+20**	1 +20**	—

*Above 1800 counts. **1kHz max. Above 5A derate 0.15% rdg/amp for self-heating.

SETTLING TIME: 2 seconds to within 15 counts of final reading.

GENERAL

DISPLAY: 4½-digit LCD, 0.5" height; polarity, function, range, and status indication.

RANGING: Auto or manual on DCV, ACV, and ohms; manual on ACA and DCA.

AUTORANGING TIME: 300ms per range.

RELATIVE: Pushbutton allows zeroing of on range readings. Allows readings to be made with respect to baseline value. Front panel annunciator indicates REL mode.

DATA LOGGER and MIN/MAX: 100 reading storage capacity; records data at one of six selectable rates from 3 rdg/s to 1 rdg/hr. Also detects and stores **maximum** and **minimum** readings continuously while in the data logger mode.

CONVERSION RATE: 3 readings/second.

OVERRANGE INDICATION: "OL" displayed.

CREST FACTOR (ratio of peak value to rms value), AC FUNCTIONS: 3.

MAXIMUM COMMON MODE VOLTAGE: 500V peak.

COMMON MODE REJECTION RATIO (1kΩ unbalance): Greater than 120dB at DC, 50Hz, 60Hz ±0.15%. Greater than 60dB in AC volts.

TEMPERATURE COEFFICIENT (0°-18°C & 28°-50°C): 0.1 × applicable accuracy specification/°C except ±(0.07%+2)/°C for 50Hz-10kHz on ACV.

ENVIRONMENT: Operating: 0° to 50°C; less than 80% relative humidity up to 35°C; linearily derate 3% RH/°C, 35° to 50°C. **Storage:** −25° to +60°C.

POWER: 105-125V or 210-250V (external switch selected), 90-110V available; 50-60Hz, 12V•A. Optional 6-hour battery pack, Model 1758.

DIMENSIONS, WEIGHT: 89mm high × 235mm wide × 275mm deep (3½" × 9¼" × 10¾"). Net weight: 1.8kg (3lbs., 14 oz.).

ACCESSORIES SUPPLIED: Model 1751 Shrouded Test Leads, instruction manual.

Prices and specifications subject to change without notice.

TABLE OF CONTENTS

Paragraph	Title	Page
	SECTION 1—GENERAL INFORMATION	
1.1	Introduction	1-1
1.2	Getting Started	1-1
1.3	Unpacking and Inspection	1-1
1.4	Specifications	1-2
1.5	Warranty Information	1-2
1.6	Manual Addenda	1-2
1.7	Safety Symbols and Terms	1-2
1.8	Optional Accessories	1-2
	SECTION 2—BENCH OPERATION	
2.1	Introduction	2-1
2.2	High Energy Circuit Precautions	2-1
2.3	Preparation for Use	2-1
2.3.1	Line Power	2-1
2.3.2	Battery Pack Power	2-1
2.3.3	Battery Charging	2-1
2.4	Front Panel Familiarization	2-2
2.4.1	Display	2-2
2.4.2	Front Panel Controls	2-2
2.4.3	Input Terminals	2-3
2.4.4	Current Fuse Replacement	2-3
2.5	Error Messages	2-3
2.6	Operating Conditions	2-3
2.6.1	Environmental Conditions	2-3
2.6.2	Maximum Allowable Input	2-4
2.7	Basic Bench Measurements	2-4
2.7.1	Power-Up	2-4
2.7.2	Relative Mode	2-4
2.7.3	DC Voltage Measurements	2-4
2.7.4	TRMS AC Voltage Measurements	2-5
2.7.5	Resistance Measurements	2-5
2.7.6	Current Measurements (DC or TRMS AC)	2-6
2.7.7	AC Plus DC Measurements	2-6
2.7.8	dB Measurements	2-6
2.7.9	dB Measurement Considerations and Applications	2-8
2.7.10	MIN/MAX and 100 Point Logger Operation	2-9
2.7.11	Diode Test	2-9
2.8	TRMS Consideration	2-9
2.8.1	AC Voltage Offset	2-9
2.8.2	TRMS Measurements Comparison	2-9
2.8.3	Crest Factor	2-10
2.8.4	Extended Frequency Response	2-10
	SECTION 3—PERFORMANCE VERIFICATION	
3.1	Introduction	3-1
3.2	Environmental Conditions	3-1
3.3	Recommended Test Equipment	3-1
3.4	Initial Conditions	3-1
3.5	Verification Procedure	3-1
3.5.1	DC Voltage Accuracy Check	3-1
3.5.2	AC Voltage Accuracy Check	3-2
3.5.3	Resistance Accuracy Check	3-2
3.5.4	DC Current Accuracy Check	3-2
3.5.5	AC Current Accuracy Check	3-3

TABLE OF CONTENTS

Paragraph	Title	Page
	SECTION 4—THEORY OF OPERATION	
4.1	Introduction	4-1
4.2	Overall Functional Description	4-1
4.3	Analog Circuitry	4-1
4.3.1	Multiplexer	4-2
4.3.2	Input Buffer Amplifier	4-2
4.3.3	-2V Reference Source	4-2
4.3.4	A/D Converter	4-2
4.3.5	Input Signal Conditioning	4-3
4.3.6	AC Converter	4-4
4.4	Digital Circuitry	4-5
4.4.1	Microcomputer	4-5
4.4.2	Address Decoding	4-5
4.4.3	PIA	4-5
4.4.4	Display Board	4-5
4.5	Digital Calibration	4-5
4.6	Power Supply	4-5
4.7	Model 1758 Battery Option	4-5
	SECTION 5—MAINTENANCE	
5.1	Introduction	5-1
5.2	Top Cover Removal/Installation	5-1
5.3	Battery Pack (Model 1758) Installation	5-1
5.4	Troubleshooting	5-1
5.4.1	Recommended Test Equipment	5-1
5.4.2	Self Diagnostic Program	5-2
5.4.3	Power Supply Checks	5-4
5.4.4	A/D Converter and Display	5-4
5.4.5	Signal Conditioning	5-4
5.5	Line Fuse Replacement	5-6
5.6	Special Handling of Static Sensitive Devices	5-6
5.7	Front Panel Calibration	5-7
5.7.1	Recommended Calibration Equipment	5-7
5.7.2	Calibration Jumper	5-7
5.7.3	Environmental Conditions	5-7
5.7.4	DC Voltage Calibration	5-7
5.7.5	AC Voltage Calibration	
5.7.6	Resistance Calibration	5-8
5.7.7	Frequency Compensation	5-8
5.7.8	Calibration Storage	5-9
	SECTION 6—REPLACEABLE PARTS	
6.1	Introduction	6-1
6.2	Replaceable Parts	6-1
6.3	Ordering Information	6-1
6.4	Factory Service	6-1
6.5	Component Location Drawings and Schematic Diagrams	6-1

LIST OF ILLUSTRATIONS

Figure	Title	Page
2-1	Model 175 Front Panel	2-2
2-2	DC Voltage Measurements	2-5
2-3	TRMS AC Voltage Measurements	2-5
2-4	Resistance Measurements	2-6
2-5	Current Measurements Between 2000mA and 20A	2-6
2-6	Current Measurements up to 2000mA	2-6
2-7	Model 175 Typical AC Frequency Response	2-11
4-1	Simplified Block Diagram	4-1
4-2	Simplified Schematic of the Multiplexer	4-2
4-3	Simplified Schematic of the Input Buffer Amplifier	4-2
4-4	A/D Converter	4-3
4-5	Resistance Measurements Ratiometric Technique	4-4
4-6	Simplified Schematics of Ohms Circuitry	4-4
5-1	Segment Identification	5-2
5-2	Calibration Jumper	5-9
6-1	Model 175 Exploded View	6-2
6-2	Model 175 Display Assembly	6-3
6-3	Display Board, Component Location Drawing, Dwg. No. 175-110	6-9
6-4	Model 1758 Battery Pack, Component Location Drawing, Dwg. No. 1755-100	6-11
6-5	Mother Board, Component Location Drawing, Dwg. No. 175-100	6-13
6-6	Mother Board, Schematic Diagram, Dwg. No. 175-106	6-17
6-7	Display Board, Schematic Diagram, Dwg. No. 175-116	6-21
6-8	Model 1758 Battery Pack, schematic Diagram, Dwg. No. 1758-106	6-23

LIST OF TABLES

Table	Title	Page
2-1	Error Messages	2-3
2-2	Model 175 Maximum Allowable Inputs	2-3
2-3	dB Specifications for DC Volts (600Ω Ref)	2-7
2-4	dB Specifications for AC Volts (600Ω Ref)	2-7
2-5	Levels for Other Reference Impedances	2-8
2-6	Comparison of Average and TRMS Meter Readings	2-10
3-1	Equipment Specifications	3-1
3-2	Limits for DC Voltage Verification	3-2
3-3	Limits for AC Voltage Verification	3-2
3-4	Limits for Resistance Verification	3-2
3-5	Limits for DC Current Verification	3-2
5-1	Recommended Troubleshooting Equipment	5-2
5-2	Troubleshooting Modes	5-3
5-3	Power Supply Checks	5-5
5-4	A/D Converter Checks	5-5
5-5	Display Board Checks	5-6
5-6	Static Sensitive Devices	5-6
5-7	Recommended Calibration Equipment	5-7
5-8	DC Voltage Calibration	5-8
5-9	AC Voltage Calibration	5-8
5-10	Resistance Calibration	5-9
6-1	Mother Board, Parts List	6-4
6-2	Display Board, Parts List	6-7
6-3	Model 1758 Battery Pack, Parts List	6-7
6-4	Model 1758 Spare Parts List	6-8

SAFETY PRECAUTIONS

The following safety precautions should be observed before operating the Model 175.

This instrument is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read over the manual carefully before operating this instrument.

Exercise extreme caution when a shock hazard is present at the instrument's input. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V rms or 42.4V peak are present. A good safety practice is to expect that a hazardous voltage is present in any unknown circuit before measuring.

Inspect the test leads for possible wear, cracks or breaks before each use. If any defects are found, replace with test leads that have the same measure of safety as those supplied with the instrument.

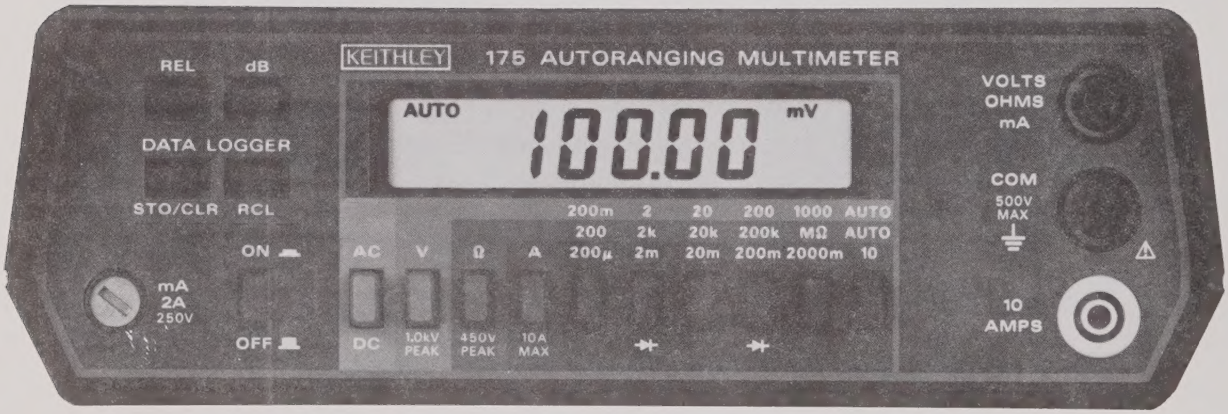
For optimum safety do not touch the test leads or the instrument while power is applied to the circuit under test. Turn the power off and discharge all capacitors, before connecting or disconnecting the instrument.

Do not touch any object which could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface, capable of withstanding the voltage being measured.

Exercise extreme safety when testing high energy power circuits (AC line or mains, etc.). Refer to the operation section.

Do not exceed the instrument's maximum allowable input as defined in the specifications and operation section.

MODEL 175 AUTORANGING DMM



Features:

- 4½ Digit LCD Display
- Fast Autoranging
- Bench or Portable
- Digital Calibration
- 100 Point Data Logger
- 10μV/10mΩ/10nA Sensitivity
- 0.03% Basic DCV Accuracy
- TRMS AC
- dBm/Relative Functions
- Min/Max Reading Hold
- Safety Input Jacks
- 10A Capability
- 100kHz Specified AC Bandwidth

Options:

- Model 1758 Rechargeable Battery Pack
- Model 1753 IEEE-488 Interface

SECTION 1
GENERAL INFORMATION

1.1 INTRODUCTION

This instruction manual contains the necessary information for operating and maintaining the Model 175 Autoranging Multimeter and the Model 1758 Rechargeable Battery Pack. The information is divided into the following sections:

1. Section 1 contains general information and provides guidelines for using this manual. Important safety information is also presented here.
2. Section 2 contains detailed bench operation information for the Model 175.
3. Section 3 contains the information needed to verify the accuracy of the Model 175. Performance verification can be done upon receipt of the unit or whenever the basic accuracy is in question.
4. For the more technically oriented, information on theory of operation, and maintenance and servicing is contained in Section 4 through 6.

NOTE

The Model 1753 IEEE-488 interface comes supplied with its own instruction manual.

1.2 GETTING STARTED

Perform the following steps in sequence to acquaint yourself quickly and safely with the basic operation of the Model 175.

1. Verify that the Model 175 was not damaged in transit, as explained in paragraph 1.3.
2. Carefully read the safety precautions and warnings found preceding this section and the first two sections (General Information and Bench Operation) of this manual.
3. Referring to paragraph 2.3.1 (Line Power) set the line voltage switch and plug the power cord into a properly grounded outlet. If the optional battery pack is installed the charge circuitry will be activated.
4. Acquaint yourself with the controls and display of the Model 175 as follows:
   A. Turn on the Model 175 by pressing in the ON/OFF pushbutton. All of the zeroes will be displayed briefly.
   B. Connect the supplied test leads to the VOLTS/OHMS/mA and COM input jacks, and short them together.
   C. Select AC volts and autoranging by pressing in the AC/DC, V and AUTO pushbuttons. The AC, mV and AUTO annunciators will be displayed. Pressing any of the other range pushbuttons will put the Model 175 in manual ranging as indicated by the absence of the AUTO annunciator.
   D. Select DC volts by releasing (out) the AC/DC pushbutton (V still selected). The AC annunciator will turn off.
   E. Select autoranging ohms by pressing in the Ω pushbutton (DC still selected) and AUTO pushbutton. The Ω annunciator will turn on. Press the AC/DC pushbutton in (AC selected) and note the "Err" message indicating that this is an invalid mode.
   F. Select AC or DC current by setting the AC/DC pushbutton accordingly and pressing in the A pushbutton. The annunciator that reflects the selected range will turn on. Note that current will not autorange and that the 10 AMPS and COM input jacks must be used on the 10A range.
   G. Select dB by placing the Model 175 in AC or DC volts and pressing the dB pushbutton. The dB annunciator will turn on. Press the dB button again to take the Model 175 out of the dB measurement mode.
   H. REL (relative) can be used with any measurement function: volts, ohms, amps or dB. For example, place the Model 175 in ohms and autorange. The display will read approximately 00.14Ω, which is the test lead resistance. Press the REL pushbutton. The REL annunciator will turn on and the display will now read 00.00Ω. The relative level of 0.14Ω will be subtracted from all subsequent ohm measurements. Press the REL pushbutton a second time to cancel the REL level.
   I. To activate the 100 point DATA LOGGER with MIN/MAX, press and hold in the STO/CLR pushbutton. When the reading rate R = 0 is displayed let go of the button. The STO annunciator will turn on. Press the RCL pushbutton and the last data point will be displayed briefly followed by the reading (data). Other data points can be displayed by holding in the RCL button. Turn off the DATA LOGGER by pressing the STO/CLR pushbutton again.
5. When you are comfortable with the controls of the Model 175, go on and make the desired measurements using Section 2, Bench Operation as a guide.

1.3 UNPACKING AND INSPECTION

The Model 175 Bench DMM was carefully inspected, both mechanically and electrically, before shipment. Upon receiving the Model 175, carefully unpack all items from the shipping carton and check for any obvious signs of physical damage that might have occurred during shipment. Report the damage to the shipping agent immediately. Retain the

original packing materials in case reshipment becomes necessary. The following items are included with every Model 175 order:

- Model 175 Autoranging Multimeter
- Model 175 Instruction Manual
- Model 1751 Safety Test Lead
- Additional accessories as ordered.

1.4 SPECIFICATIONS

Detailed Model 175 specifications may be found immediately preceding the table of contents of this manual.

1.5 WARRANTY INFORMATION

Warranty information may be found on the inside back cover of this manual. Should it be necessary to exercise the warranty, contact your Keithley representative or the factory to determine the correct course of action. Keithley Instruments maintains service facilities in the United States, West Germany, Great Britain, France, the Netherlands, Switzerland and Austria. Information concerning the application, operation or service of your instrument may be directed to the applications engineer at any of theses locations. Check the inside front cover of this manual for addresses.

1.6 MANUAL ADDENDA

Information concerning improvements or changes to the instrument which occur after the printing of this manual will be found on an addendum sheet included with this manual. Be sure to review these changes before attempting to operate or service the instrument.

1.7 SAFETY SYMBOLS AND TERMS

The following safety symbols and terms are used in this manual or found on the Model 175.

The symbol on the instrument indicates that the user should refer to the operating instructions in this manual.

The symbol on the instrument indicates that a potential of 1000V or more may be present on the terminal(s). Standard safety practices should be observed when such dangerous voltages are encountered.

The **WARNING** heading in this manual explains dangers that could result in personal injury or death.

The **CAUTION** heading in this manual explains hazards that could damage the instrument.

1.8 OPTIONAL ACCESSORIES

The following accessories can be used with the Model 175.

Model 1010 Single Rack Mounting Kit—Use to mount one Model 175 in a standard 5 ¼ X 19" rack.

Model 1017 Dual Rack Mounting Kit—Use to mount two Model 175's in a standard 5 ¼ X 19" rack.

Model 1301 Temperature Probe—A rugged low cost temperature probe designed to allow precision temperature measurements from -55°C to 150°C.

Range: -55°C to 150°C
Output: 1mV/°C; compatible with any DMM with at least 10MΩ input impedance.
Accuracy: ±2°C from 0° to 100°C; ±3°C from -55° to 0°C and 100° to 150°C
Power: 9V alkaline or C-Zn (NEDA 1604) battery.

Model 1600A High Voltage Probe—Extends the DMM to 40kV.

Maximum Input: 40kV DC or peak AC to 300Hz
Input Resistance:1000MΩ
Division Ratio: 1000:1
Ratio Accuracy: ±2.5% from 1kV to 40kV DC, ±3.5% if 200mV or 2V ranges of Model 175 are used; -3dB at 300Hz AC
Operating Temperature: 0° to 50°C

Model 1651 50-Ampere Current Shunt—The external 0.001Ω ±1%, 4-terminal shunt permits current measurements from 0-50A DC or AC.

Model 1681 Clip-On Test Lead Set—contains two leads, 1.2m (48 inches) long terminated with banana plugs and spring action clip on probes.

Model 1682A RF Probe—Permits voltage measurements from 100kHz to 250MHz.

AC to DC transfer accuracy: ±1dB from 100kHz to 250MHz at 1V, peak responding, calibrated in rms of a sine wave.
Maximum Allowable Input: 42V AC peak, 200V (DC + AC peak)

Model 1684 Hard Shell Carrying Case—Hard vinyl case, 100mm × 300mm × 350mm (4 × 13 × 14 inches) has a fitted foam insert with room for the Model 175, instruction manual and small accessories.

Model 1685 Clamp-On AC Probe—Measures AC current by clamping onto a single conductor. Interruption of the circuit under test is unnecessary. The Model 1685 detects current by sensing the changing magnetic field produced by the current flow.

Range: 2, 20 and 200A rms
Accuracy: ±4% of range at 60Hz; ±6% of range at 50Hz
Temperature Coefficient: ±0.05%/°C on 20A and 200A range; ±0.3%/°C on 2A range
Maximum Allowable Current: 300A rms
Maximum Conductor Voltage: 600V rms
Conversion Ratio: 0.1V/A rms

Model 1751 Safety Test Leads—This is the test lead set supplied with each Model 175. Finger guards and shrouded banana plugs help minimize the chance of making contact with live circuitry.

Model 1753 IEEE-488 Interface—Field installable programmable option provides isolated data output. Switch-selectable talk only or addressable modes. Mounts within and powered by the Model 175.

Model 1754 Universal Test Lead Kit—12 piece test lead kit, with interchangeable plug-in accessories. Kit includes: one set of test leads(1-red, 1-black), two spade lugs, two standard banana plugs, two phone tips (.060DIA.), two hooks and two miniature alligator clips (with boots).

Model 1758 Rechargeable Battery Pack—Provides six hours minimum operation from full charge, recharges within 10 hours and is field installable.

Model 7008 IEEE-488 Digital Cable-Useful for connecting the Model 1753 to the IEEE-488 bus. The Model 7008-3 is 0.9m (3ft) in length and has a standing IEEE-488 connector at each end. The Model 7008-6 is 1.8m (6ft) in length.

SECTION 2
BENCH OPERATION

2.1 INTRODUCTION

This section contains the information needed to prepare and operate the Model 175 as a bench DMM. Bench operation consists of using the Model 175 to perform basic voltage, current, resistance and dB measurements. Also, the operation of the data logger is covered here. The capabilities of the Model 175 can be enhanced with the addition of the Model 1753 IEEE-488 interface. IEEE operation is covered in the Model 1753 Instruction Manual.

2.2 HIGH ENERGY CIRCUIT PRECAUTIONS

To optimize safety when measuring voltage in high energy distribution circuits, read and use the directions in the following warning.

WARNING

Dangerous arcs of an explosive nature in a high energy circuit can cause severe personal injury or death. If the meter is connected to a high energy circuit when set to a current range, low resistance range or any other low impedance range, the circuit is virtually shorted. Dangerous arcing can result even when the meter is set to a voltage range if the minimum safety spacing is reduced.

When making measurements in high energy circuits use test leads that meet the following requirements:

1. Test leads should be fully insulated.
2. Only use test leads that can be connected to the circuit (e.g. alligator or spade plugs) for hands-off measurement.
3. Do not use test leads that decrease voltage spacing. This diminishes arc protection and creates a hazardous condition.

Use the following sequence when testing power circuits:

1. De-energize the circuit using the regular installed connect-disconnect device such as the circuit breaker, main switch, etc.
2. Attach the test leads to the circuit under test. Use appropriate safety rated leads for this application.
3. Set the DMM to the proper function and range.
4. Energize the circuit using the installed connect-disconnect device and make measurements without disconnecting the DMM.
5. De-energize the circuit using the installed connect-disconnect device.
6. Disconnect the test leads from the circuit under test.

2.3 PREPARATION FOR USE

2.3.1 Line Power

The Model 175 is provided with a three-wire line cord which mates with third-wire grounded receptacles. Connect the instrument to AC line power as follows:

1. Set the LINE VOLTAGE switch on the back of the instrument to correspond to line voltage available. Ranges are 105-125V or 210-250V 50/60Hz AC.

CAUTION

Connect only to the line voltage selected. Application of incorrect voltage can damage the instrument.

2. Plug the power cord into a properly grounded outlet.

WARNING

Ground the instrument through a properly grounded receptacle before operation. Failure to ground the instrument can result in severe injury or death in the event of short circuit or malfunction.

NOTE

Although the Model 175 is specified at 50 and 60Hz the instrument may be operated at 400Hz and 440Hz. Add one count to instrument specifications under this condition.

2.3.2 Battery Pack Power

The Model 175 may also be operated from rechargeable sealed nickel-cadmium batteries contained in the optional Model 1758 Rechargeable Battery Pack. The battery pack will operate the Model 175 for up to six hours. The BAT annunciator will turn on when the battery charge is insufficient to maintain accurate readings. Refer to Section 5, paragraph 5.3 for installation procedures.

2.3.3 Battery Charging

After the Model 1758 Battery Pack is installed in the Model 175 it can be charged and recharged as follows:

1. Connect the instrument to line power as described in paragraph 2.3.1.
2. With the power switch off, the battery charge circuitry is automatically energized to charge the battery at the maximum rate. When the battery pack is first installed, or if it is completely discharged, allow it to charge for ten hours.

NOTE

For maximum battery efficiency only charge the battery pack after it has become discharged and only charge until it is fully charged (≈10hours). Continuous charging over long periods of time will not damage the batteries but, useful life will gradually decrease. This loss is not permanent and may be restored by cycling the battery pack through several complete charge/discharge cycles. The battery pack is capable of 500 to 1000 charge/discharge cycles before replacement is needed.

Do not make measurements with the BAT annunciator on as the readings may be erroneous.

3. When the Model 175 is in use on line power, the battery charger maintains a trickle charge on the battery pack.

2.4 FRONT PANEL FAMILIARIZATION

The following paragraphs and Figure 2-1 provide a brief description of the display, front panel controls and input terminals.

2.4.1 Display

The Model 175 has a 4 ½ digit liquid crystal display (LCD). The minus sign is displayed. The plus sign is implied by the absence of the minus sign. The following annunciators are displayed on the LCD.

BAT—Low battery indicator for the Model 1758.

AC—AC selected (DC implied by absence of AC annunciator).

mV or V—Millivolts or volts selected.

Ω, kΩ or MΩ—Ohms, kilohms or megohms selected.

μ, mA or A—Microamps, milliamps or amps selected.

RMT (Remote)—Model 175 being controlled over the IEEE-488 bus (Model 1753 installed).

C—Model 175 in calibration mode.

AUTO—Autorange selected.

REL—Relative selected.

dB—Decibel selected.

STO—Data being stored.

RCL—Data being recalled. RCL flashes when buffer is full during logging cycle.

2.4.2 Front Panel Controls

ON/OFF—Pressing in this pushbutton turns the Model 175 on. Releasing (out) this pushbutton turns the instrument off.

REL (Relative)—This pushbutton allows readings to be made with respect to any baseline value. Also allows zeroing of on range readings. See paragraph 2.7.2 for more detailed information on REL.

dB—This pushbutton selects the dB function and is used along with the ACV or DCV function. Measurements are made in dBm referenced to 600Ω. REL can be used to make any voltage level the 0dB reference point for dB measurements.

DATA LOGGER—Has min/max and 100 point reading storage capacity; records data at one of six selectable rates from every reading to 1 rdg/hr. Records maximum and minimum conversion during the period the data logger is active at the rate of 3/sec.

1. **STO/CLR**—Pressing this button initiates the logging sequence. Pressing the button a second time shuts off the data logger.
2. **RCL**—Pressing and holding this button in scrolls the data pointer. To read the data at a particular point, simply release the button.

AC/DC—This switch is used along with the volts (V), current (A), and dB functions. Depressing (in) this pushbutton selects AC and releasing (out) this pushbutton selects DC.

V—Depressing this pushbutton selects the volts function.

Ω—Depressing this pushbutton selects the ohms function. The AC/DC pushbutton must be released (out).

A—Depressing this pushbutton selects the current function.

Range Push Buttons

1. **AUTO**—Depressing this pushbutton causes volts and ohms to autorange. In current, it selects the 10A range (no autoranging in current).

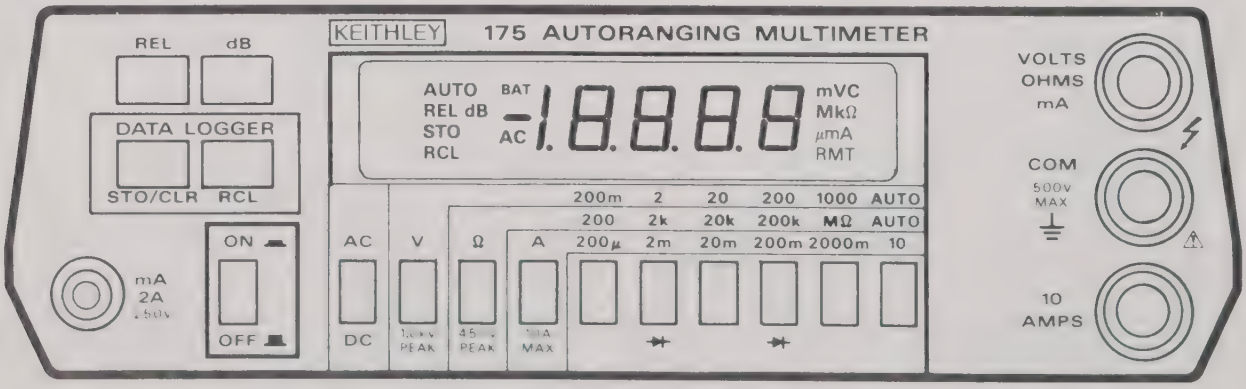


Figure 2-1. Model 175 Front Panel

2. Manual ranging is accomplished by depressing the appropriate range button.

2.4.3 Input Terminals

The input terminals are intended to be used with safety shrouded test leads to help minimize the possibility of contact with live circuits. Safety shrouded test leads are supplied with the Model 175.

VOLTS/OHMS/mA and COM (Red and Black)—Use this pair of terminals for all volt, ohm, milliamp and dB measurements.

10 AMPS and COM (White and Black)—Use this pair exclusively for measuring current up to 10A (up to 20A for 15 seconds).

2.4.4 Current Fuse Replacement

The current fuse protects the 200μA through 2000mA ranges from an input current greater than 2A. To replace the current fuse, perform the following steps:

1. Turn off the power and disconnect the power line and test leads.
2. Place the end of a flat-blade screwdriver into the slot in the fuse holder on the front panel. Press in slightly and rotate the fuse carrier one-quarter turn counterclockwise. Release pressure and remove the fuse carrier and the fuse.
3. Remove the defective fuse and replace it with the following type: 2A, 250V, 3AG, normal-blow Keithley part number FU-13, or equivalent.

CAUTION

Use only the recommended fuse type. If a fuse with a higher current rating is installed, instrument damage may occur.

2.5 ERROR MESSAGES

Table 2-1 lists the error messages associated with basic front panel operation. Note that the instrument has a number of other messages that are discussed in the appropriate sections of this manual.

2.6 OPERATING CONDITIONS

2.6.1 Environmental Conditions

All measurements should be made at an ambient temperature within the range of 0°C to 50°C, and with a relative humidity of 0% to 80% up to 35°C. For instruments above 35°C derate humidity 3% per °C up to 50°C. If the instrument has been subjected to extremes of temperature, allow sufficient time for internal temperatures to reach environmental conditions. Typically, it takes one hour to stabilize a unit that is 10°C (18°F) out of specified temperature range.

Table 2-1. Error Messages

Display	Message	Comments
0000	RAM Error	Model 175 locks up. See Section 5 for troubleshooting information.
cErr	Calibration Error (NVRAM Failure)	Model 175 locks up, but operation can be restored by pressing any one of the four momentary pushbuttons. If restored, calibration is invalid as indicated by the flashing "C" annunciator. See Section 5 for troubleshooting information.
OL	Overrange	Overrange input applied to the Model 175. Leading minus sign indicates that input signal has a negative value.
AC Err Ω	Invalid Ω Function	"AC" and "Ω" annunciators flash. Correct problem by releasing (out) AC/DC pushbutton.

Table 2-2. Model 175 Maximum Allowable Inputs

Function	Ranges	Maximum Allowable Inputs
DCV	200mV, 2V	1000VDC or peak AC for less than 10sec per minute. 300Vrms continuous.
	20-1000V	1000VDC or peak AC.
ACV	200mV	750Vrms 1000V peak for less than 10sec per minute. 300Vrms continuous. 10^7V•Hz maximum.
	2-750V	750Vrms, 1000V peak. 10^7V•Hz maximum.
DCA, ACA	200μ-2000mA	2A, 250VDC or rms (fuse protected).
	10A	10A continuous; 20A for 15sec (unfused).
Ω	All	450VDC or peak AC

2.6.2 Maximum Allowable Inputs

Table 2-2 lists the maximum allowable inputs for the Model 175.

2.7 BASIC BENCH MEASUREMENTS

Basic measurement techniques for using the Model 175 to measure AC and DC volts, resistance, AC and DC current and dB are covered in the following paragraphs. Also included is the operation of the MIN/MAX and 100 point data logger.

WARNING

Before operating the Model 175, observe the safety precautions found preceding Section 1. When testing high energy power circuits follow the procedure found in paragraph 2.2 High Energy Circuit Precautions. Failure to observe these and other safety precautions found in this manual could result in severe injury or death.

The COM terminal on the Model 175 is designed to float above earth ground to avoid ground loop problems.

WARNING

Hazardous voltages may be applied to the COM terminal. The maximum allowable voltage between the COM terminal and chassis ground is 500V. Destruction of insulation, which could present a shock hazard, may occur if the 500V maximum is exceeded.

CAUTION

Do not exceed the maximum input limits shown in Table 2-2.

2.7.1 Power-Up

NOTE

The software revision level of the Model 175 can be displayed upon power-up by running the diagnostic program. See Section 5, Maintenance, for more information.

Turn on the Model 175 by pressing in the ON/OFF switch. The following will occur:

1. Reset-All zeros will be briefly displayed before going into the measurement mode.
2. RAM Test-If this test fails the Model 175 will lock up with zeros displayed.
3. NVRAM Test-If this test fails the display will show the error message "cErr"

Refer to Table 2-1 for more information pertaining to error messages.

2.7.2 Relative Mode

When the relative mode is selected with an on-scale reading on the display the following occurs:

1. The REL annunciator is displayed.
2. The next reading is stored.
3. The stored reading is then algebraically subtracted from all subsequent readings and displayed.

A REL level can be established for any measurement function (Volts, Ohms, Amps and dB) and is effective only on that function. Changing functions will not affect a REL level already established. However, if another REL level is set (on any function) the previous REL level will be cancelled. For example, place the 175 in the Ω function and select the 200Ω range. Short the test leads and press the REL button. Note that the REL annunciator is on. Select DCV and note that the REL annunciator is off, indicating that there is not a REL level established for DCV. Switch back to Ω and note that the REL level is still there. Again, go to DCV and set a REL level of +1V. The REL annunicator will go on. Switch back to Ω and note that the REL annunciator is off, indicating that the REL level for Ω is cancelled.

Once a REL level is established for a measurement function, that stored level will be the same regardless of what range the Model 175 is on. For example, if +1V is established as the REL level on the 20VDC range, +1V will also be the REL level on the 1000VDC range.

It is important to note that the use of REL reduces the dynamic range of measurements by that level. For instance, assume that the REL level is +1V and the Model 175 is manually set to the 2V range. The maximum positive displayed reading, before overranging, would be +0.9999V. This is because the A/D converter would be seeing 1.9999V (maximum) from the input. Thus, the dynamic range of measurement is -1.9999V to +0.9999V (2.9998V) as compared to the normal -1.9999V to +1.9999V (3.9998V). The dynamic range of measurement has been reduced by 1V. The effects on dynamic range can be reduced by selecting a higher range or using autorange.

2.7.3 DC Voltage Measurements

The Model 175 can make DC voltage measurements between 10μV and 1000V. The basic procedure is as follows:

1. Connect the test leads to the VOLTS and COM terminals of the Model 175.
2. Select the DCV function.
3. Select a range consistent with the expected voltage. For automatic range selection, press in the AUTO pushbutton.

NOTE

Manual ranging is recommended for routine measurements above 200V.

4. Connect the test leads to the source as shown in Figure 2-2. If the positive source terminal is connected to the COM terminal of the instrument, the display will show a negative value. If the negative source terminal is connected to the COM terminal, the display will show a positive value.
5. Observe the display; if the "OL" message is shown, select a higher range until a normal reading is shown. Always use the lowest possible range for the best resolution.
6. Take the reading from the display.

NOTE

High input impedance (V1000MΩ) DC volts measurements can be made on the 200mV and 2V ranges by releasing (out) all the function pushbuttons (AC/DC, V, Ω, A).

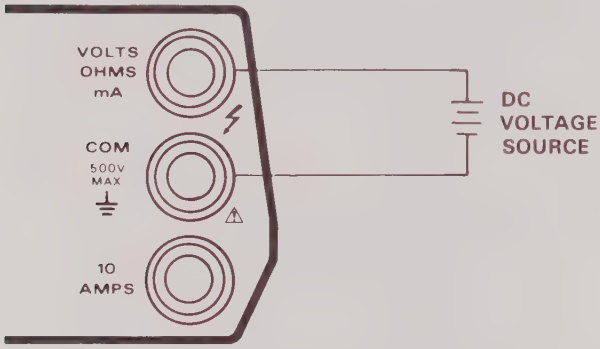


Figure 2-2. DC Voltage Measurements

2.7.4 TRMS AC Voltage Measurements

The Model 175 can make TRMS AC voltage measurements between 10μV and 750V. Proceed as follows:

1. Connect the test leads to the VOLTS and COM terminals of the Model 175.
2. Select the ACV function.
3. Select a range consistent with the expected voltage. For automatic range selection, press in the AUTO pushbutton.

NOTE

Manual ranging is recommended for routine measurements above 200V.

4. Connect the test leads to the source as shown in Figure 2-3.
5. Observe the display; if the "OL" message is shown, select a higher range until a normal reading is shown. Always use the lowest possible range for the best resolution.
6. Take the reading from the display.

NOTE

See paragraph 2.8 for TRMS considerations.

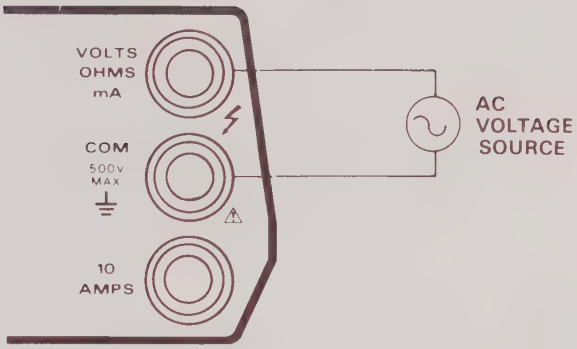


Figure 2-3. TRMS AC Voltage Measurements

2.7.5 Resistance Measurements

The Model 175 can make resistance measurements between 10mΩ and 200MΩ. The 2MΩ, 20MΩ and 200MΩ ranges will autorange when the MΩ pushbutton is pressed in. Proceed as follows to make resistance measurements:

1. Connect the test leads to the OHMS and COM terminals of the Model 175.
2. Select the Ω function.

NOTE

The message "Err" and flashing Ω and AC annunciators will be displayed if the AC/DC pushbutton is pressed in. This is an invalid mode. To correct, simply release (out) the AC/DC pushbutton.

3. Select a range consistent with the expected resistance. For automatic range selection, use the autorange mode.

NOTE

Zeroing may be necessary to compensate for test lead resistance on the 200Ω and 2kΩ ranges. Zero the display as follows:

A. Short the test leads together.
B. Press the REL pushbutton. The display will zero.
C. Proceed to step 4.

4. Connect the test leads to the resistance to be measured as shown in Figure 2-4.
5. Observe the display; if the "OL" message reading is shown, select a higher range until a normal reading is shown. Always use the lowest possible range for the best resolution.
6. Take the reading from the display

NOTE

It is helpful to shield resistances greater than 10^6Ω (1MΩ) if a stable reading is expected. Place the resistance in a shielded enclosure and electrically connect the shield to COM of the Model 175.

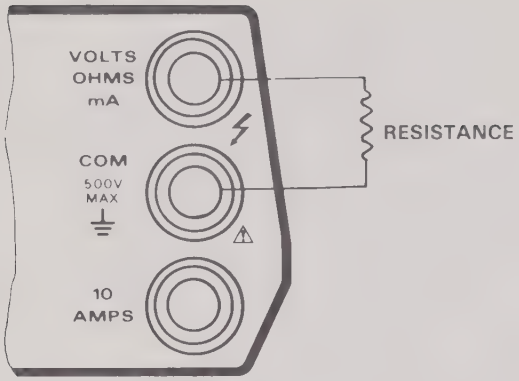


Figure 2-4. Resistance Measurements

2.7.6 Current Measurements (DC or TRMS AC)

The Model 175 can make DC or TRMS AC current measurements between 10μA and 10A (20A for 15 seconds). If the expected current level is in question, make the initial measurement with the 10A range. This will help prevent the inadvertent blowing of the 2A current fuse.

NOTE

For routine measurements above 10A it is recommended that the Model 1651, 50-Ampere current shunt be used.

1. For current measurements between 2000mA and 20A.
   A. Connect the test leads to the 10 AMPS and COM terminals of the Model 175.

NOTE

The test leads used must be capable of handling 20A and it is recommended that they be twisted (see Figure 2-5) to minimize external fields which could affect the Model 175 or other equipment. Also, keep the test leads as short as possible to minimize voltage drop.

   B. Select the ACA or DCA function.
   C. Select the 10A range. Current does not autorange.
   D. Connect the test leads to the current source as shown in Figure 2-5 and make the reading from the display.

NOTE

Up to 5A may be applied continuously without degradation of the measurement due to self-heating effects. Above 5A derate 0.15% rdg per amp for self-heating. For currents between 10A and 20A, specified accuracy can only be obtained when measurements are limited to a maximum of 15 seconds.

2. For current measurements up to 2000mA:
   A. Connect the test leads to the mA and COM terminals of the Model 175.
   B. Select the ACA or DCA function.
   C. Select an appropriate range for the expected current. Current measurements cannot autorange.
   D. Connect the test leads to the current source as shown in Figure 2-6. If an overrange indication is displayed select a higher range until a normal reading is shown. Use the lowest possible range for the best accuracy.
   E. Make the reading from the display.

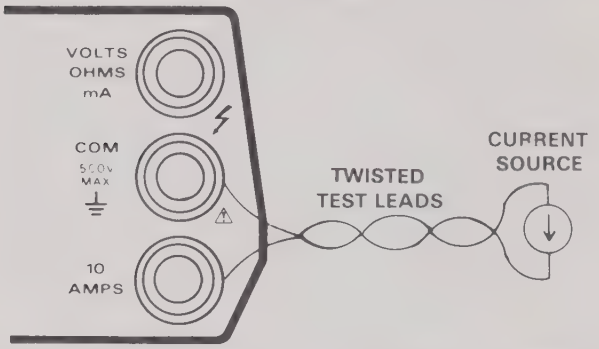


Figure 2-5. Current Measurements Between 2000mA and 20A

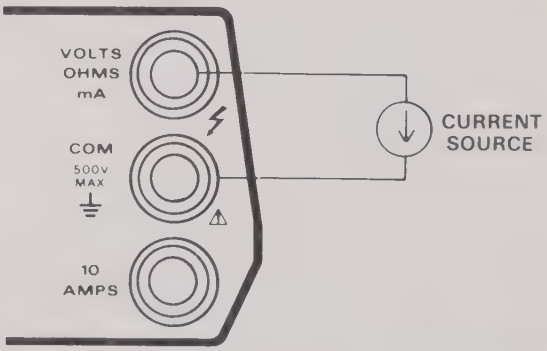


Figure 2-6. Current Measurements up to 2000mA

2.7.7 AC Plus DC Measurements

Use the Model 175 to measure TRMS on a signal which has both AC and DC components as follows:

1. Measure and record the TRMS AC component as described in paragraph 2.7.4.
2. Measure and record the DC component as described in paragraph 2.7.3.
3. Compute the rms value from the following equation:

$$E_{RMS} = \sqrt{E_{DC}2 + E_{AC}2}$$

2.7.8 dB Measurements

The dB function makes it possible to compress a large range of readings into a much smaller scope. The relationship between dB and voltage can be expressed by the following equation.

$$dB = 20 \log \frac{V_{OUT}}{V_{REF}}$$

Tables 2-3 and 2-4 list the dB specifications for DC volts and AC volts.

The Model 175 can make dBm measurements referenced to the standard 600Ω impedance or to other impedances. The relative feature allows measurements in dB independent of impedance.

The basic procedure for placing the instrument in the dB mode is to first select AC or DC volts and then press the dB button. Note that once dB is selected (dB annunciator on), pressing in the Ω or A function pushbuttons will turn dB off.

1. dBm Measurements with 600Ω Reference Impedance

   dBm is defined as decibels above or below a 1mW reference. The standard reference impedance of the Model 175 is 600Ω. What that means is that the Model 175 is designed to read 0dBm when the calculated voltage needed to dissipate 1mW through a 600Ω impedance is applied to the Model 175. That calculated voltage level is 0.7746V as derived from the basic power equation.

   $E = \sqrt{P \bullet R}$

   $E = \sqrt{10^{-3}W \bullet 600\Omega}$

   $E = 0.7746V$

   Thus with a 600Ω reference impedance the Model 175 will read 0dBm whenever 0.7746V is applied.

   NOTE

   Do not confuse reference impedance with input impedance. The input impedance of the instrument is still 10MΩ (see specifications) in the dB mode.

   To make dBm measurements referenced to 600Ω, proceed as follows:

   A. Connect the test leads to the VOLTS and COM terminals of the Model 175.
   B. Select the ACV or DCV function.
   C. Select autorange for optimum resolution.
   D. Press the dB button.
   E. Connect the test leads to the voltage source.
   F. Make the dBm reading from the display.

2. dBm Measurements with Other Reference Impedances

   dBm measurements can be made with other reference impedances. The most convenient method for using other reference impedances is to algebraically subtract the calculated dB offset for the desired reference impedance from the reading on the display of the Model 175. Table 2-5 lists common reference impedances and the corresponding offset values. The following equation can be used to calculate the offset for impedances not listed in Table 2-5:

   $$\text{Offset (for dBm)} = 10 \log \frac{\text{New ref Z}}{600\Omega}$$

   To make dBm measurements referenced to another impedance, proceed as follows:

   A. Choose the desired reference impedance.
   B. Calculate or look up the offset value in Table 2-5 for the desired reference impedance.
   C. Determine dBm at the desired reference impedance as follows:

      dBm (at ref Z) = 175 reading - offset

      Example: Make dBm measurements references to a 100Ω reference impedance.

Table 2-3. dB Specifications for DC Volts (600Ω Ref).

Linear Counts	Resolution	Accuracy
10 - 99	1 dBm	±1 dBm
100 - 999	0.1 dBm	±0.1 dBm
1000 - 20000	0.01dBm	±0.02dBm

Table 2-4. dB Specifications for AC Volts (600Ω Ref)

dB Mode (ref: 600Ω)		Accuracy (±dBm)			
Range	Input	20Hz-10kHz	10kHz-20kHz	20kHz-50kHz	50kHz-100kHz
200mV	1mV to 2mV (-58 to -52dBm)	2*	—	—	—
	2mV to 20mV (-52 to -32dBm)	2	3	—	—
	20mV to 200mV (-32 to -12dBm)	0.2	0.3	1	—
2V-750V	200mV to 750V (-12 to +59.8dBm)	0.2	0.26	0.56	1.2

*Up to 1kHz

i. 100Ω is not listed in Table 2-5 so the offset must be calculated as follows:

$$\text{Offset} = 10 \log\left(\frac{100\Omega}{600\Omega}\right)$$

$$\text{offset} = -7.78\text{dB}$$

ii. Subtract -7.78dB from all subsequent displayed readings on the Model 175.

dBm measurements, referenced to another impedance, can be read directly from the display of the Model 175 by utilizing the REL feature, and an accurate voltage source. The basic procedure is as follows:

A. Calculate or look up the equivalent voltage level (Table 2-5) for 0dBm at the desired reference impedance.

B. Input that voltage level to the Model 175.

C. With the Model 175 in the dB mode, press the REL button.

D. dBm measurements referenced to the desired impedance can now be read directly from the display of the Model 175.

3. dBW Measurements

dBW is defined as decibels above or below a one watt reference. The procedure is the same as that found in paragraph 2.7.8 step 2. The only difference is that the reference point is 0dBW (1W) rather than 0dBm (1mW).

4. dBV Measurements

dBV is defined as decibels above or below 1V (0dBV point). This is a voltage relationship independent of impedance. The basic procedure is to simply subtract 2.22 dB (Table 2-5) from all subsequent displayed readings on the Model 175..

5. Relative dB Measurements

Just about any voltage level within the measurement limits of the Model 175 can be established as the 0dB point. The basic procedure is to establish that level as the 0dB point by using REL and make the desired dB measurements.

Table 2-5. Levels for Other Reference Impedances

Reference Impedance (Ω)	Equiv. Voltage Level for: 0dBm	0dBW	Offset (600Ω Ref) 0dBm	0dBW
8	0.0894	2.828	-18.75	11.25
50	0.2236		-10.79	
75	0.2739		- 9.03	
150	0.3873		- 6.02	
300	0.5477		- 3.01	
600	0.7746		0.00	
1000	1.0000		2.22	

$V_{equiv.}$ for 0dBm $= \sqrt{10^{-3}W \bullet Z_{REF}}$

$V_{equiv.}$ for 0dBW $= \sqrt{Z_{REF}}$

$$\text{Offset (for dBm)} = 10 \log\left(\frac{Z_{REF}}{600\Omega}\right)$$

$$\text{Offset (for dBW)} = 10 \log\left(\frac{Z_{REF}}{600\Omega \bullet .001}\right)$$

2.7.9 dB Measurement Considerations and Applications

1. Typical Instrument Performance

Typically, the Model 175 will perform better than its published dB specification. The following example will illustrate this point:

A. Using the Model 175 in the dB mode (600Ω ref) measure a 1mV RMS, 1kHz source (common application in the communications field). Typically, the Model 175 will read -57.7dBm.

B. The calculated dBm level for that source is -57.8dBm.

C. The 0.1dBm error is considerably better than the ±2dBm specification. The specifications are intended to cover worst measurement conditions.

2. Measuring Circuit Gain/Loss

Any point in a circuit can be established as the 0dB point. Measurements in that circuit are then referenced to that point expressed in terms of gain (+dB) or loss (-dB). To set the 0dB point:

A. Place the Model 175 in volts, autorange and dB.

B. Connect the Model 175 to the desired location in the circuit.

C. Press the REL button. The display will read 0dB.

D. Gain/Loss measurements can now be made referenced to the 0dB point.

3. Measuring Bandwidth

The Model 175 can be used to determine the bandwidth of an amplifier as follows:

A. Connect a signal generator to the input of the amplifier.

B. Set the Model 175 to ACV and autorange.

C. Connect the DMM and a frequency counter to the load of the amplifier.

D. Adjust the frequency of the signal generator until a peak AC voltage reading is measured on the Model 175.

E. Press the dB button and then press the REL button. The 0dB point is now established.

F. Increase the frequency input until the Model 175 reads -3.00dB. The frequency measured on the frequency counter is the high end limit of the bandwidth.

G. Decrease the frequency input until the dB reading again falls to -3dB. The frequency measured on the signal generator is the low end limit of the bandwidth.

4. Determining Q

The Q of a tuned circuit can be determined as follows:

A. Determine the center frequency and bandwidth as explained in paragraph 2.7.9 step 3.

B. Calculate Q by using the following formula:

$$Q = \text{Center Frequency/Bandwidth}$$

2.7.10 MIN/MAX and 100 Point Data Logger Operation

The data logger can store up to 100 readings and store the minimum and maximum readings recorded during the period that the data logger is active. The Data Logger remains active even after 100 points of data are stored, which means the MIN/MAX readings continue to update. The only way to deactivate the Data Logger is to press the STO/CLR button (STO annunciator off) or cycle power. The 100 points of data are stored at one of six selectable rates from three per second to one reading per hour. Readings for minimum and maximum are sampled at the rate of three per second regardless of the selected rate. The procedure for operating the data logger is as follows:

1. Connect the desired measurement configuration to the Model 175. Make sure that the controls of the Model 175 are set appropriately.
2. Logging Data:
   A. Press and hold the STO/CLR pushbutton. The following reading rates will scroll on the display:
      r = 0 (every reading)
      r = 1 (1 rdg/sec)
      r = 2 (1 rdg/10 sec)
      r = 3 (1 rdg/min)
      r = 4 (1 rdg/10 min)
      r = 5 (1 rdg/hr)

      NOTE

      There is no need to select a rate if just minimum/maximum readings are desired. Momentarily press the STO/CLR button to start the logger.

   B. Release the STO/CLR pushbutton when the desired reading rate is displayed. The STO annunciator will turn on and data will be logged at the selected rate.

      NOTE

      The logging cycle can be terminated at any time by pressing the STO/CLR button. This shuts off the data logger. However, data is retained and can be recalled at any time as long as the instrument remains on.
3. Data Retrieval

   Data can be retrieved at any time, but a flashing RCL annunciator indicates that the maximum number of readings (100) have been stored.
   A. Press and hold in the RCL pushbutton. The display will scroll through the data points and MIN/MAX (LO/HI). The first data point displayed will be the last stored reading. The next two data points will be the HI and LO readings made during that logging cycle. Notice that the longer the RCL pushbutton is held in the faster the data points will scroll on the display.
   B. Release the RCL pushbutton at the desired data point and note the reading (data) on the display. The data pointer can be incremented by steps of one by momentarily holding in the RCL pushbutton.
4. Shut off the data logger by pressing the STO/CLR pushbutton. All stored data will be retained until a new store cycle has commenced.

2.7.11 Diode Test

The 2kΩ and 200kΩ ranges can be used for testing semiconductor junctions as follows:

1. Select Ω function.
2. Press 2k and 200k pushbuttons (diode symbols) in simultaneously.
3. Display reads forward V drop of diode at 0.7mA (up to 2V). Red terminal is positive.

2.8 TRMS CONSIDERATIONS

Most DMMs actually measure the average value of an input waveform but are calibrated to read its RMS equivalent. This poses no problems as long as the waveform being measured is a pure, low-distortion sine wave. For complex, non-sinusodial waveforms, however, measurements made with an averaging type meter can be grossly inaccurate. Because of its TRMS (True Root Mean Square) measuring capabilities, the Model 175 provides accurate AC measurements for a wide variety of AC input waveforms

2.8.1 AC Voltage Offset

Typically the Model 175 will display 25 counts or less of offset on AC volts with the input shorted. This offset is caused by amplifier noise and offset of the TRMS converter. This offset will not affect reading accuracy and should not be zeroed out using the REL feature. The following equation expresses how this offset (V_{OFFSET}) is added to the signal input (V_{IN}):

$$\text{Displayed reading} = \sqrt{(V_{IN})^2 + (V_{OFFSET})^2}$$

As long as V_{IN} is at least 10 times larger than V_{OFFSET}, negligible error will occur.

Example: Range = 2VAC range
Offset = 25 counts
Input = 200mV RMS

$$\begin{aligned}\text{Displayed Reading} &= \sqrt{(0.2)^2 + (.0025)^2} \\ &= \sqrt{0.04 + 0.0000063} \\ &= \sqrt{0.0400063} \\ &= .2000\text{V RMS}\end{aligned}$$

If REL is used to zero the display, the 25 counts of offset would be subtracted from V_{IN} resulting in an error of 25 counts in the displayed reading.

2.8.2 TRMS Measurement Comparison

The RMS value of a pure sine wave is equal to 0.707 times its peak value. The average value of such a waveform is 0.637 times the peak value. Thus, for an average-responding meter, a correction factor must be designed in. This correction factor, K, can be found by dividing the RMS value by the average value as follows:

$$K = \frac{0.707}{0.637} = 1.11$$

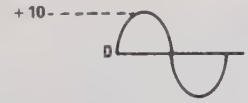
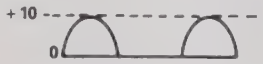
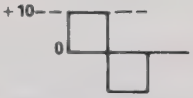
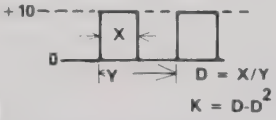
By applying this correction factor to an averaged reading, a typical meter can be designed to give the RMS equivalent. This works fine as long as the waveform is a pure sine wave, but the ratios between the RMS and average values of different waveforms is far from constant, and can vary considerably.

Table 2-6 shows a comparison of common types of waveforms. For reference, the first waveform is an ordinary sine wave with a peak altitude of 10V. The average value of this voltage is 6.37V, while its RMS value is 7.07V. If we apply the 1.11 correction factor to the average reading, it can be seen that both meters will give the same reading, resulting in no error in the average-type meter reading.

The situation changes with the half-wave rectified sine wave. As before, the peak value of the waveform is 10V, but the average value drops to 3.18V. The RMS value of this waveform is 3.86V, but the average responding meter will give a reading of 3.53V (3.18 × 1.11), creating an error of 11%.

A similar situation exists for the rectified square wave, which has an average value of 5V and an RMS value of 7.07V. Here, the average responding meter gives a reading of 5.55V (5 × 1.11), while the Model 175 gives a TRMS reading of 5V. Other waveform comparisons can be found in Table 6-2.

Table 2-6. Comparison of Average and TRMS Meter Readings

Waveform	Peak Value	RMS Value	Average Responding Meter Reading	AC Coupled TRMS Meter Reading	Averaging Meter Percent Error
Sine 	10V	7.07V	7.07V	7.07V	0%
Half-Wave Sine 	10V	3.86V	3.53V	3.86V	8.5%
Full-Wave Sine	10V	3.08V	2.98V	3.08V	3.2%
Square 	10V	10.00V	11.10V	10.00V	11%
Rectified Square Wave	10V	5.00V	5.55V	5.00V	11%
Rectangular Pulse 	10V	10K	11.1K	10K	11%
Triangular Sawtooth	10V	5.77V	5.54V	5.77V	4%

2.8.3 Crest Factor

The crest factor of a waveform is the ratio of its peak value to its RMS value. Thus, the crest factor specifies the dynamic range of a TRMS instrument. For sinusodial waveforms, the crest factor is 1.414. For a symmetrical square wave, the crest factor is unity.

The crest factor of other waveforms will, of course, depend on the waveform in question because the ratio of peak to RMS value will vary. For example, the crest factor of a rectangular pulse is related to its duty cycle; as the duty cycle decreases, the crest factor increases. The Model 175 has a crest factor of 3, which means the instrument will give accurate TRMS measurements of rectangular waveforms with duty cycles as low as 10%.

2.8.4 Extended Frequency Response

Figure 2-7 illustrates the extended frequency response of the AC volts ranges up to 1MHz.

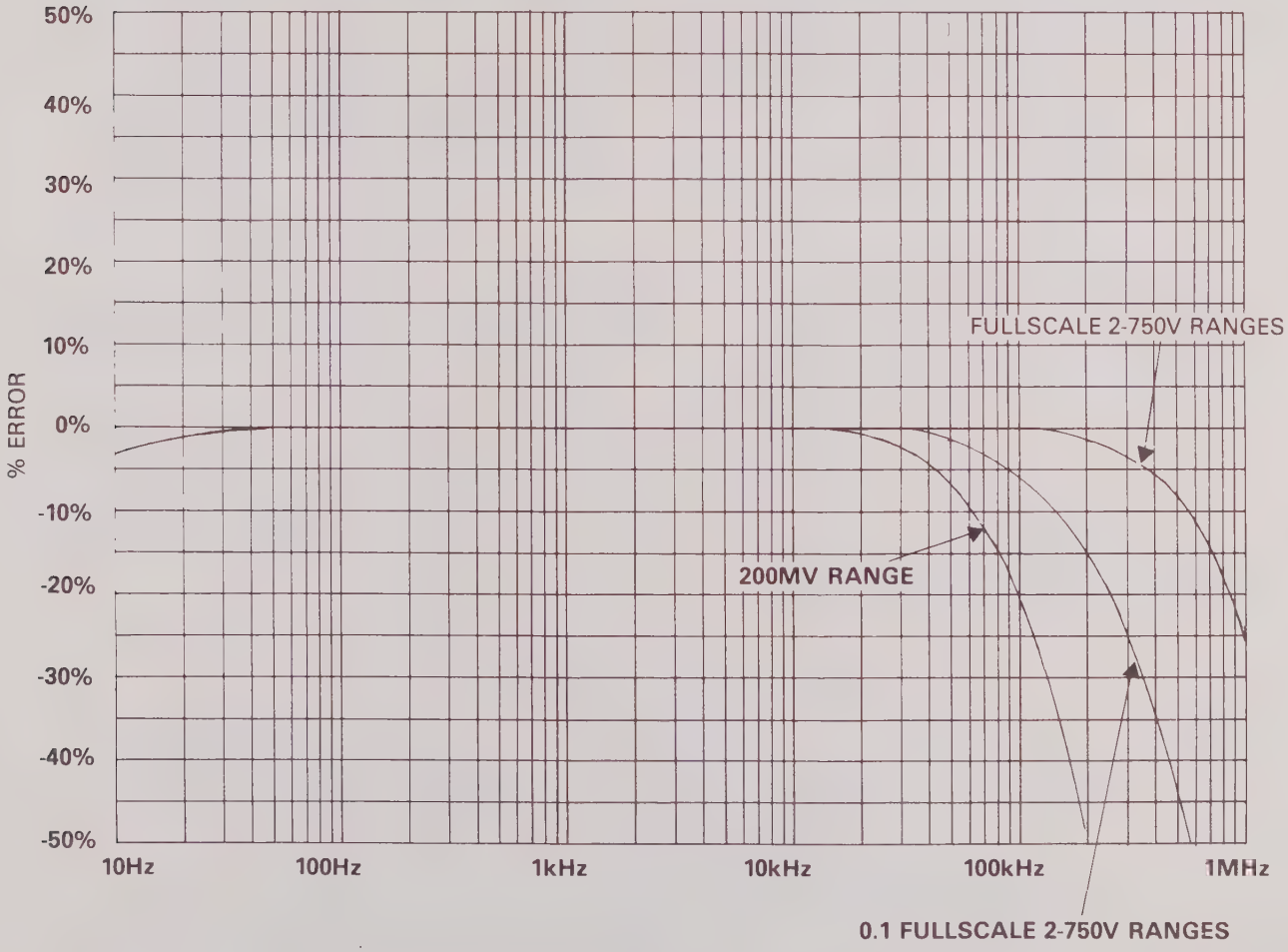


Figure 2-7. Model 175 Typical ACV Frequency Response

SECTION 3
PERFORMANCE VERIFICATION

3.1 INTRODUCTION

This section contains information necessary to verify that the Model 175's performance is within specified accuracy Model 175 specifications may be found at the front of this manual. Ideally, performance verification should be performed when the instrument is first received to ensure that no damage or change in calibration has occurred during shipment. The verification procedure may also be performed whenever instrument accuracy is suspect or following calibration. If performance on any of the ranges or functions is substandard, calibration can be performed as described in Section 5.

NOTE

If the instrument does not meet specifications and it is still under warranty (less than 12 months since date of shipment), contact your Keithley representative or the factory to determine the action to be taken.

3.2 ENVIRONMENTAL CONDITIONS

All measurements should be made at an ambient temperature between 18° and 28°C (65° to 82°F) with a relative humidity less than 80%.

3.3 RECOMMENDED TEST EQUIPMENT

Equipment for verifying the performance of the Model 175 is listed in Table 3-1. Alternate equipment may be used as long as the equipment accuracy is at least as good as the specifications listed in Table 3-1.

3.4 INITIAL CONDITIONS

Before performing the verification procedures, make sure the Model 175 meets the following conditions:

1. If the instrument has been subject to temperatures below 18°C (65°F) or above 28°C (82°F), allow sufficient time for the instrument to reach temperatures within the range. Generally, it takes one hour to stabilize an instrument that is 10°C (18°F) outside of this range.
2. Turn on the Model 175 DMM and allow it to warm up for ten minutes. The instrument may be operated from either line power or battery pack power, as long as the battery pack has been fully charged as described in paragraph 2.3.3.

3.5 VERIFICATION PROCEDURE

The following paragraphs give the basic verification procedure for the following functions: DC volts, AC volts, resistance, and current.

WARNING

The following procedures require that high voltages may be applied to the input terminals of the Model 175. Use normal precautions to avoid possible electrical shock which could result in personal injury or death.

3.5.1 DC Voltage Accuracy Check

CAUTION

Do not exceed 1000V between the VOLTS/OHMS/mA and COM terminals or damage to the instrument may occur.

Table 3-1. Equipment Specifications

Mfg	Model	Description	Specifications
Fluke	5101B	DC Voltage Calibrator	200mV, 2V, 20V, 200V, 1000V ranges ±0.005%
		AC Voltage Calibrator	200mV, 2V, 20V, 100V 50Hz to 10kHz, ±0.05%
		Resistance Calibrator	100Ω, 1kΩ, 10kΩ, 100kΩ ranges ±0.005%; 1MΩ range ±0.01%; 10MΩ range ±0.05%
		DC Current Calibrator	200μA, 2mA, 20mA, 200mA, 2000mA ranges ±0.025%
Fluke	5200A	AC Voltage Calibrator	100mV, 1V, 10V, 100V ranges: 20Hz—50Hz ±0.1% 20kHz—100kHz ±0.05%
Fluke	5205A	Power Amplifier	1000V range: 10Hz—30Hz ±0.12% 50kHz—100kHz ±0.10%

1. Select the DC V function and 200mV range.
2. Connect the calibrator to the instrument.
3. Apply positive 100.000mVDC to the Model 175. The reading must be within the limits specified in Table 3-2.
4. For each remaining range, apply the required voltage as specified in Table 3-2, and verify that the reading is within specifications.
5. Repeat all checks with negative voltage.

Table 3-2. Limits for DC Voltage Verification

DCV Range	Applied DC Voltage	Allowable Readings (18°C to 28°C)
200mV	100.000mV	99.95 to 100.05
2V	1.00000V	0.9996 to 1.0004
20V	10.0000V	9.996 to 10.004
200V	100.000V	99.96 to 100.04
1000V	1000.00V	999.6 to 1000.4

3.5.2 AC Voltage Accuracy Check

CAUTION

Do not exceed 750V RMS, 1000V peak 10^7V•Hz, between the VOLTS/OHMS/mA and COM terminals or instrument damage may occur.

1. Select the AC V function and the 200mV range.
2. Connect the calibrator to the DMM.
3. Set the calibrator output to 100.000mV AC at a frequency of 20Hz. Verify that the reading is within the limits specified in Table 3-3.
4. Repeat the 100mV AC measurement at the other frequencies specified in Table 3-3.
5. Check the 2V, 20V, 200V, and 750V ranges by applying the required voltages and frequencies specified in Table 3-3 and verifying that the readings are within the specified limits.

3.5.3 Resistance Accuracy Check

CAUTION

Do not exceed 450VDC or peak AC between the VOLTS/OHMS/mA and COM terminals or instrument damage may occur.

1. Select the Ω function (AC/DC pushbutton must be out) and the 200Ω range.
2. Connect the test leads to the Model 175 and short the other ends together.
3. Press the REL pushbutton to compensate for the test lead resistance.
4. Disconnect the short and connect the test leads to the calibrator.
5. Set the calibrator to 100.000Ω and verify that the reading is within the limits specified in Table 3-4.
6. Check the 2kΩ, 20kΩ, 200kΩ, and MΩ ranges by applying the required resistances specified in Table 3-4 and verifying that the readings are within the specified limits.

Table 3-4. Limits for Resistance Verification

Ω Range	Applied Resistance	Allowable Readings (18°C to 28°C)
200Ω	100.000Ω	99.93 to 100.07
2kΩ	1.00000kΩ	0.9994 to 1.0006
20kΩ	10.0000kΩ	9.993 to 10.007
200kΩ	100.000kΩ	99.94 to 100.06
2MΩ	1.00000MΩ	0.9993 to 1.0007
20MΩ	10.0000MΩ	9.979 to 10.021

3.5.4 DC Current Accuracy Check

CAUTION

Do not exceed 2A to the VOLTS/OHMS/mA and COM terminals or the amp fuse will blow.

1. Select the DC A function and initially, the 2000mA range.
2. Connect the calibrator to the VOLTS/OHMS/mA and COM terminals of the Model 175.
3. Apply 100.000μA and switch the Model 175 to the 200μA range. The reading must be within the limits specified in Table 3-5.
4. Check the 2mA through 2000mA ranges by applying the required current specified in Table 3-5 and verifying that the readings are within the specified limits.

CAUTION

Do not exceed 10A continuously or 20A for 15 seconds to the 10 AMPS and COM terminals or instrument damage may occur.

Table 3-3. Limits for AC Voltage Verification

ACV Range	Applied AC Voltage	Allowable Readings (18°C + 28°C)					
		20Hz	50Hz	10kHz	20kHz	50kHz	100kHz
200mV	100.000mV	98.80 to 101.20	99.30 to 100.70	99.30 to 100.70	98.10 to 101.90	91.25 to 108.75	—
2V	1.00000V	0.9980 to 1.0120	0.9930 to 1.0070	0.9930 to 1.0070	0.9860 to 1.0140	0.9675 to 1.0325	0.9300 to 1.0700
20V	10.0000V	9.880 to 10.120	9.930 to 10.070	9.930 to 10.070	9.860 to 10.140	9.675 to 10.325	9.300 to 10.700
200V	100.000V	98.80 to 101.20	99.30 to 100.70	99.30 to 100.70	98.60 to 101.40	96.75 to 103.25	93.00 to 107.00
750V	750.00V	740 to 759.5	744.2 to 755.8	744.2 to 755.8	—	—	—

5. Set the Model 175 to the 10A range and connect the DC current source to the 10 AMPS and COM terminals.
6. Apply a current of 1.90000A to the Model 175. The reading must be within the limits specified in Table 3-5.

3.5.5 AC Current Accuracy Check

Since AC current uses the same circuitry as AC volts and DC current already checked in paragraphs 3.5.2 and 3.5.4, no additional accuracy checks are necessary.

Table 3-5. Limits for DC Current Verification

DCA Range	Applied DC Current	Allowable Readings (18°C to 28°C)
200μA	100.000μA	99.83 to 100.17
2mA	1.00000mA	0.9983 to 1.0017
20mA	10.0000mA	9.983 to 10.017
200mA	100.000mA	99.78 to 100.22
2000mA	1000.00mA	997.8 to 1002.2
10A	1.90000A	1.885 to 1.914

SECTION 4
THEORY OF OPERATION

4.1 INTRODUCTION

This section contains an overall functional description of the Model 175. Information pertaining to the Model 1758 Battery Pack option is also included. Detailed schematics and component layout drawings are located at the end of this instruction manual.

4.2 OVERALL FUNCTIONAL DESCRIPTION

The Model 175 is a 4 ½ digit ±20,000 count DMM with five AC and DC voltage ranges, 7 resistance ranges and 5 AC and DC current ranges. A simplified block diagram of the Model 175 is shown in Figure 4-1. The heart of the Model 175 is the A/D converter that translates the conditioned analog input signals into a form usable by the microcomputer.

4.3 ANALOG CIRCUITRY

The following paragraphs contain a description of the input multiplexer, buffer amplifier, -2V reference and A/D converter circuits. These circuits may be found on schematic diagram number 175-106 located at the end of this manual.

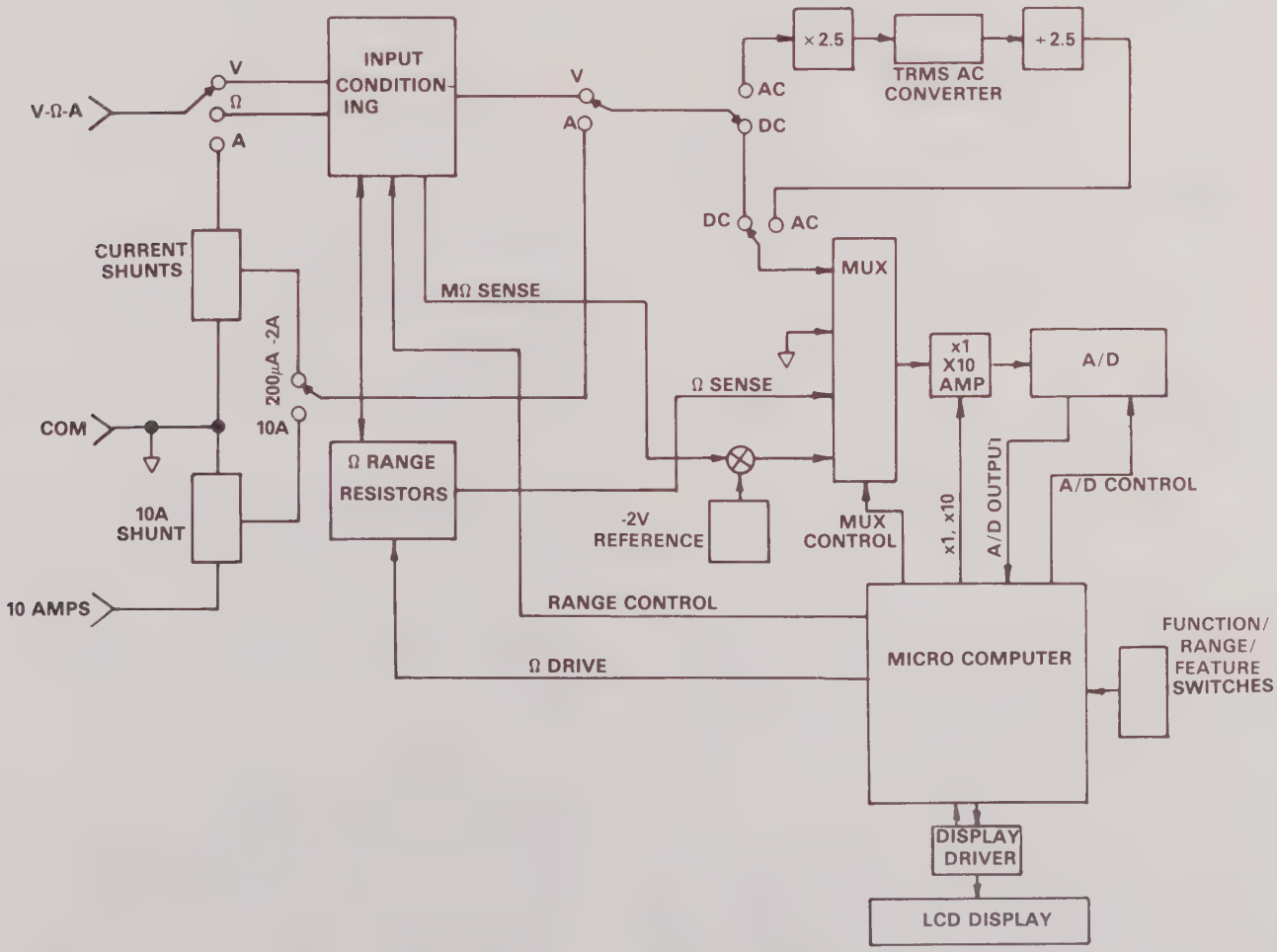


Figure 4-1. Similplified Block Diagram

4.3.1 Multiplexer

The multiplexer connects one of four signals to the buffer amplifier: Signal, zero, reference, ohms reference. The multiplexer, shown in Figure 4-2, is made up of 4 JFETS which are controlled by the microprocessor through U114. The FETs are driven by U109 and part of U106. The drivers convert the digital signals of the microprocessor to signals usable by the FETs.

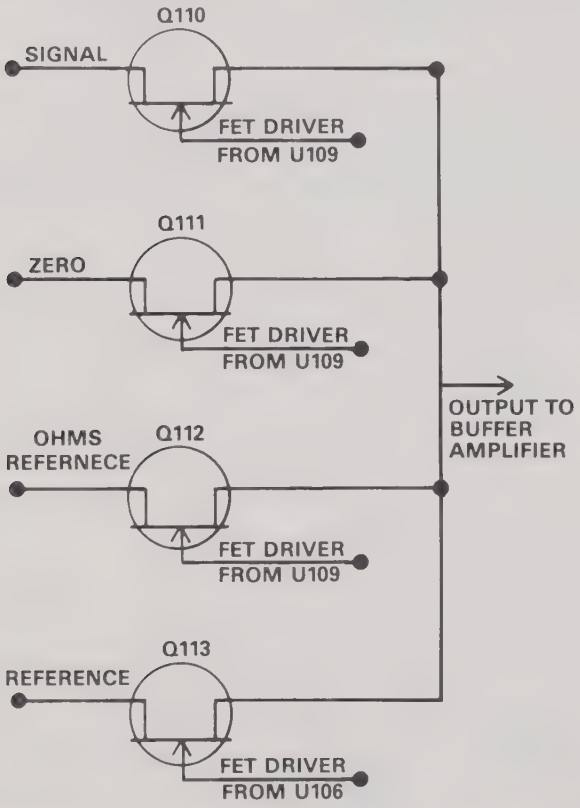


Figure 4-2. Simplified Schematic of the Multiplexer

Ordinarily, FET switching creates transients which could be seen in the final measurement. These effects are minimized in the Model 175 through the use of software generated delays and by shorting the multiplexer bus to signal common before each signal measurement through Q111.

4.3.2 Input Buffer Amplifier

The input buffer amplifier provides the necessary isolation between the input signal and the A/D converter. The amplifier is a noninverting, low noise, high impedance circuit with x1 or x10 gain. The amplifier gain is controlled by the microprocessor and is range and function dependent. Figure 4-3 shows the simplified schematic of the input buffer amplifier.

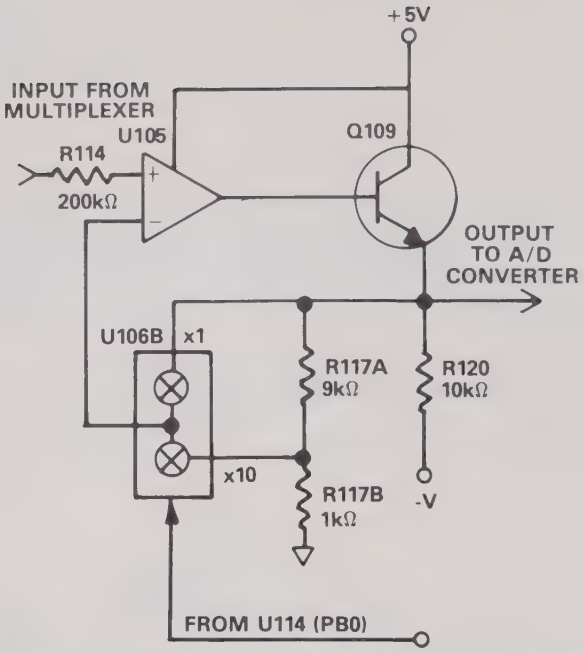


Figure 4-3. Simplified Schematic of the Input Buffer Amplifier

4.3.3 -2V Reference Source

The Model 175 voltage and current measurements are based on comparing the unknown signal with an internal -2V reference voltage. During each measurement cycle the microprocessor samples the unknown and uses it along with a zero measurement and -2V signal measurement to compute the unknown voltage.

The -2V reference is made up of a highly stable zener diode (VR101), an op-amp and a resistive voltage divider. U103 and R120 A, B, C act as a constant current source to minimize the zener voltage variations. R117 C, D is then used to divide down the -6.35V zener voltage to -2V.

The output of U103 (-7V) is used as a reference voltage for the A/D converter and as a negative supply for various components.

4.3.4 A/D Converter

The Model 175 uses a combination constant frequency charge balance, single slope analog-to-digital converter. A simplified schematic of the A/D used in the Model 175 is shown in Figure 4-4 with an associated output waveform.

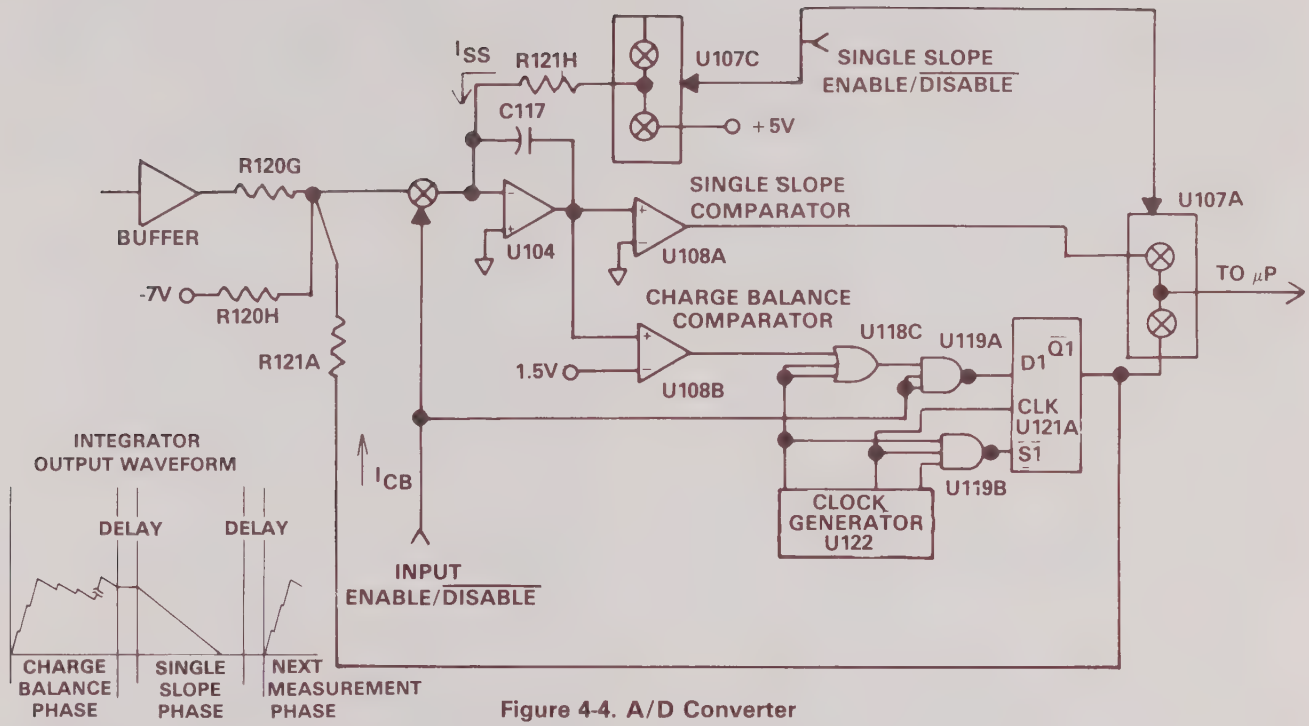


Figure 4-4. A/D Converter

The charge balance phase begins when the input enable/disable line is set high. This occurs at the end of a software-generated delay period that allows the signal to settle after the appropriate multiplexer FET is turned on. The actual delay period depends on the selected range and function.

Once this occurs the signal from the buffer amplifier is added to the offset from R120H. This converts the bipolar signal from the buffer (±2V) to an unipolar input to the integrator.

The integrator ramps up until it just passes the charge-balance comparator threshold voltage. When the rising edge of Q3 occurs from U122 or when U119 goes low, $\overline{Q}$ goes high forcing I_{CB} into the integrator input. Since I_{CB} is much greater than the current through R120G and R120H the integrator output voltage will ramp in the negative direction. The integrator will continue ramping downward until U119B goes low. Each time the output U121A goes high it is gated (inside the microprocessor) with the microprocessor's internal clock and these pulses are counted. Once U121A goes low the process repeats itself.

The charge balance phase continues for 100msec. At the end of the charge balance phase, the output of the integrator is resting at some positive voltage. Since the integrator output is connected to the noninverting input of the U108A, its output will stay high until the integrator ramps negative. During single slope Q114 is turned off and R121H is connected to +5V. The single slope comparator is then gated with the microprocessor's internal clock and counted. Once the comparator output goes low the microprocessor stops counting and can compute the reading.

4.3.5 Input Signal Conditioning

For DCV and ACV the signal conditioning is performed by R106, its shunt capacitors, K101, K102, K103 & Q106.

The following attenuation is provided:

In the DCV mode: ÷1 is used on the 200mV & 2V ranges.
÷10 is used on the 20V range.
÷100 is used on the 200V range.
÷1000 is used on the 1000V range.

In the ACV mode: ÷1 is used on the 200mV range.
÷10 is used on the 2V range.
÷100 is used on the 20V range.
÷1000 is used on the 200V & 1000V range.

Protection for the AC & DC voltage ranges is provided by R103, R108, Q107 and Q108. R103 and R108 are used exclusively on the lower ranges of ACV & DCV to limit current to Q107 and Q108 during overload. During the overload Q107 and Q108 clamp the maximum voltage on the signal FET line to within 0.7V of the supplies.

Signal conditioning for current is performed by R109, R110 and R119 current shunts. For DC current measurements the shunt voltage drop (200mV full scale) is applied directly to the input signal FET for conversion. In AC current, the shunt voltage drop is treated as a 200mV AC signal and is switched to the AC converter section. Overload clamping occurs at 3 diode voltage drops which is a level high enough to permit high crest factor current waveforms.

In DCV the properly scaled signal is applied directly to Q110 through R107 and C110. In the AC V mode the scaled analog signal is applied to the AC converter for transformation to a DC signal that is applied to Q110.

Resistance measurements are made using the ratiometric technique (see Figure 4-5). When the resistance function is selected a series circuit is formed between the ohms source, reference resistor and the external unknown resistance.

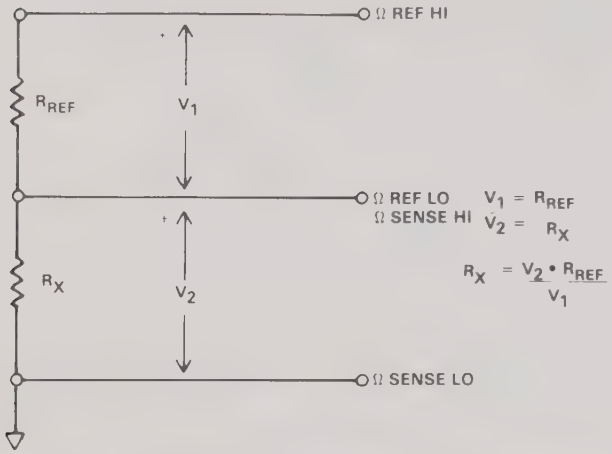
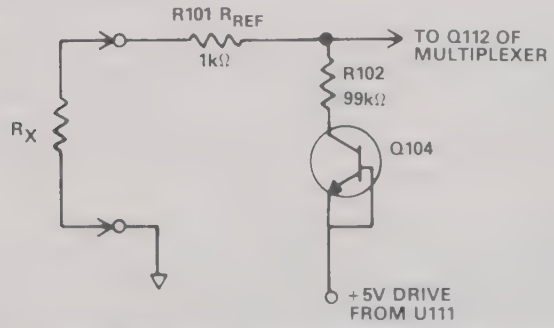


Figure 4-5. Resistance Measurements—Ratiometric Technique

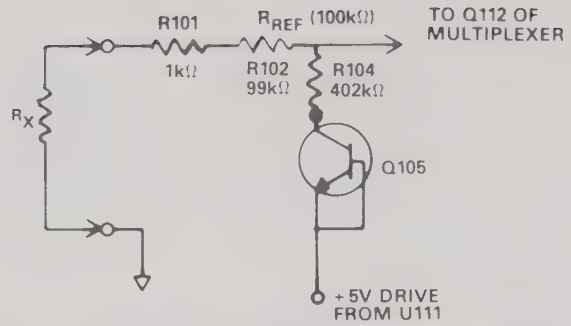
Three reference resistors are used on the ohms ranges R101, R102 and R106A. R101 is used for the 200Ω & 2kΩ ranges, R102 for the 20kΩ and 200kΩ ranges and R106A for 2MΩ, 20MΩ & 200MΩ. Drive for the ohms ranges is ultimately controlled by the microprocessor through U111 and U112.

Switching for the ohms ranges is done using low leakage base to collector diodes of Q102, Q104 and Q105. The appropriate transistor is turned on by driving the base high (+5V). The simplified schematics for the ohms circuitry is shown is Figure 4-6.



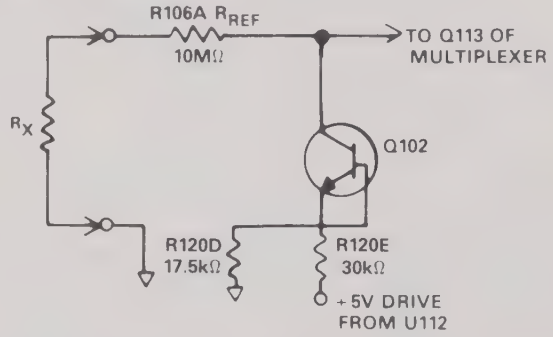
NOTE: Q102, Q103 and Q105 are reversed biased and functionally out of the circuit.

A) 200Ω and 2kΩ RANGES



NOTE: Q102, Q103 and Q104 are reversed biased and functionally out of the circuit

B) 20kΩ and 200kΩ RANGES



NOTE: Q103, Q104 and Q105 are reversed biased and functionally out of the circuit

C) 2MΩ, 20MΩ AND 200MΩ RANGES

Figure 4-6. Simplified Schematics of Ohms Circuitry

By measuring the four inputs to the A/D converter the unknown resistance can be computed by the microprocessor using this equation:

$$R_X = \frac{\Omega\text{sense HI} - \Omega\text{sense LO}}{\Omega\text{ref HI} - \Omega\text{ref LO}}$$

For the 200Ω, 20kΩ, 2MΩ ranges Ω sense HI is actually multiplied by a factor of 10 in the buffer circuit:

Protection on the ohms ranges is accomplished by Q103, RT101, Q101, R103, Q107 and Q108. For an input voltage applied to the Ω input terminals, Q101 clamps the voltage across R101 to a safe level. RT101 limits current to Q103 which clamps the voltage at Q104 to a safe limit (<12V).

For the 20kΩ and 200kΩ ranges protection is provided by R102, R104 and R105. R106A provides protection for the 2MΩ, 20MΩ and 200MΩ ranges by limiting current.

4.3.6 AC Converter

All AC voltage inputs pass through U101 for a x2.5 voltage

amplification. The gain stage is used to permit accurate voltage measurement at higher frequencies and lower input levels.

The output of U101 is applied to the TRMS converter chip which converts the AC input signal to the corresponding DC level. The DC output is then ÷2.5 and applied to the signal FET.

4.4 DIGITAL CIRCUITRY

Model 175 operation is controlled by the internal microcomputer. This section briefly describes the operation of the various sections of the microcomputer and associated digital circuitry. A simplified block diagram is included for user reference; for more complete circuit details refer to schematic diagram number 175-106 at the end of this manual.

4.4.1 Microcomputer

The microcomputer centers around the 146805E2 CMOS microprocessor. It is an 8 bit microprocessor with direct addressing of up to 8k bytes on a shared address and data bus.

Timing of the microprocessor is accomplished by the use of Y101; a 3.2768MHz crystal. Internally this frequency is divided down by 5 to obtain a bus operating frequency of 655.36kHz. This is present on the address strobe of U123 (pin 6) and supplies timing to all other parts of the instrument through the binary divider U122.

The software for the MPU is stored in U115 (PROM). Temporary storage is provided by U113. U113 is used to share the calibration constants on power up and as RAM for the microprocessor's in-house functions. It also stores readings for the data logger. U110 is the NVRAM and is used to store the calibration constants.

4.4.2 Address Decoding

U120 is used to latch in the address that is on the bus when the address strobe of U123 goes high and presents it to the PROM (U115) during data strobe.

4.4.3 PIA

U114 provides for most of the control of the instrument. It controls all ranging hardware, A/D converter, and data output and input for the IEEE option.

4.4.4 Display Board

The LCD display is driven by a flat pack LCD controller chip U201 and it communicates to the microprocessor through 4 control lines. During power-up the microprocessor configures U201 to drive the triplexed display.

In order to drive the display correctly four voltages are obtained from R126. The clock required by U201 is obtained from U122.

The display board also houses the special function keys; dB, REL, STO/CLR and RCL.

4.5 DIGITAL CALIBRATION

The Model 175 uses digital calibration to eliminate all potentiometers in the instrument to facilitate calibration. The constants that the Model 175 uses are stored in a nonvolatile electrically alterable read only memory (U110), and are read on power-up of the instrument. There is one constant for each range on DCV, ACV and Ω. On the DCV and ACA functions the 200mV DC and 200mV AC constants are used respectively.

4.6 POWER SUPPLY

Fuse F102 is the LINE FUSE which is internally accessible. S101 is the power on/off switch and S102 selects 115V or 230V operations by placing the transformer primary windings in parallel or series.

T101, the power transformer has two secondary windings; one for the Model 175 and the other for the IEEE option (Model 1753). The bridge rectifier (CR104) functions as a fullwave rectifier for both the plus and minus supplies. R123 limits current to the 12V zener (VR102) and to the batteries (if installed) for charging. The zener acts as a pre-regulator to the +5V regulator.

4.7 MODEL 1758 BATTERY OPTION

Maximum battery charging rate is achieved when the instrument is connected to line power and the on/off switch is off. Fullwave rectified voltage from CR104 is applied to R102 and BT101 to charge the batteries. Q101 acts as a current sink if the charging current rises above 150mA. The batteries are of the quick recharge type and will charge in 8 to 10 hours. With the instrument turned on the batteries will trickle charge at approximately 40mA.

With the battery pack installed, the negative supply is generated using a CMOS voltage inverter (U101). The output of the inverter is applied to CR101 and C101 for filtering.

Low battery detection is accomplished by the comparator (U102) and the microcprocessor. A voltage level of 8.8V across BT101 signals the end of useful battery life. The trip level for the comparator is set by R103 and R104.

SECTION 5
MAINTENANCE

5.1 INTRODUCTION

This section contains installation, service and calibration information for the Model 175 and 1758 Battery Pack. In addition to front panel calibration, a program for calibrating the Model 175 over the IEEE bus is included.

WARNING

The procedures described in this section are for use only by qualified service personnel. Do not perform these procedures unless qualified to do so. Many of the steps covered in this section may expose the individual to potentially lethal voltages that could result in personal injury or death if normal safety precautions are not observed.

5.2 TOP COVER REMOVAL/INSTALLATION

The top cover of the Model 175 must be removed in order to service the unit or to install the Model 1758 battery pack and/or the Model 1753 IEEE-488 interface. Proceed as follows:

WARNING

Disconnect the line cord and all other sources and cables before removing the top cover.

1. Turn off the power, disconnect the line cord and remove all test leads from the terminals of the Model 175.
2. Turn the unit over and remove the four screws from the bottom of the case.
3. Turn the unit over again and separate the top cover from the rest of the unit.
4. To reinstall the top cover, position the tilt bail properly into the bottom cover and reverse the above procedure.

5.3 BATTERY PACK (Model 1758) INSTALLATION

Refer to Figure 6-1 and perform the following procedure to install the battery pack:

WARNING

Installation of the battery pack should only be performed by qualified personnel. Disconnect line cord and remove all test leads from the terminals of the Model 175.

1. Remove the top cover as explained in paragraph 5.2.
2. Remove the shield by pulling up on either side until the back lip disengages from the retaining clip. Ease the shield out of the unit.
3. Position the battery board as shown in Figure 6-1 and secure it to the shield using two supplied screws. The screws are fed through the shield into the battery board fasteners.
4. Place the battery pack in the bracket and position it on the shield as shown. Feed the two screws through the shield into the bracket and tighten.

CAUTION

Do not allow the battery leads to short together or damage to the batteries may occur.

5. Carefully place the shield (with battery pack) back into the Model 175 so that it seats properly on the two spacers. Press down firmly on the back of the shield to engage it into the retaining (and ground) clip.
6. Connect the ribbon cable from the battery board to the male connector (marked BATTERY) on the mother board.

CAUTION

Make a close visual inspection to ensure that the connectors are properly mated or damage to the instrument may result.

7. Connect the red battery lead to the +RED terminal pin on the battery board. Connect the black battery lead to the -BLK terminal pin on the battery board.
8. Reinstall the top cover as explained in paragraph 5.2.
9. Charge the battery pack per instructions in paragraph 2.3.3.

5.4 TROUBLESHOOTING

The troubleshooting instructions contained in this section are intended for qualified personnel having a basic understanding of analog and digital circuitry. The individual should also be experienced at using test equipment as well as ordinary troubleshooting procedures. The information presented here has been written to assist in isolating a defective circuit or circuit section; isolation of the specific component is left to the technician.

NOTE

Avoid touching the PC Board or its component parts. Handle the PC Board by its edges.

5.4.1 Recommended Test Equipment

The success or failure in troubleshooting the Model 175 depends not only on the skill of the technician, but also relies heavily on accurate, reliable test equipment. Table 5-1 lists the minimum equipment and specifications recommended for troubleshooting the Model 175. Other equipment such as logic analyzers, capacitance meters, etc, could also be helpful in difficult situations.

Table 5-1. Recommended Troubleshooting Equipment

Equipment	Use
Five-function DMM with 0.05% basic DC accuracy, 10MΩ input impedance	Power supply and DC voltage checks, analog signal tracing, continuity, static logic levels.
Dual-trace, triggered-sweep oscilloscope, DC to 50MHz bandwidth.	Digital and analog waveform checks.

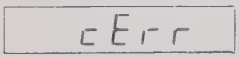
5.4.2 Self Diagnostic Program

To use the self diagnostic program, hold in the dB button and turn on the Model 175. The following will occur:

1. All LCD digits and annunciators will turn on.
2. The software revision level will be displayed (i.e. A1).
3. The sequential display test will run.
4. The Model 175 will go into the troubleshooting test mode.

If the dB button is released the instrument will flag either RAM or NVRAM self test failures, should they occur. If neither RAM nor NVRAM fails, the instrument will default to the troubleshooting test mode.

RAM Test—If the RAM test fails, the Model 175 will lock up with all zeroes displayed. Replacing U113 may correct problem.
Non-Volatile RAM Test—If the NVRAM test fails the following message will be displayed:



This is a sufficient message indicating that the instrument is probably not properly calibrated since calibration constants are stored in the non-volatile RAM. The Model 175 will lock up at this point if the test fails, but operation may be restored for troubleshooting by pressing any front panel control button. The flashing "C" annunciator will indicate that the unit failed the NVRAM test.

At this point try calibrating the instrument with the constants already entered by simultaneously pressing in REL and dB until CAL is displayed, and then again until Stor is displayed. If the error gets corrected, indicating that the NVRAM is probably good, a full calibration will be needed. If the error persists try replacing the NVRAM chip (U110). Again, the Model 175 must undergo a complete calibration after the problem is corrected.

Sequential Display Test—Segments and annunciators are sequentially displayed in eight steps. Use Figure 5-1 for segment identification. The steps are as follows:

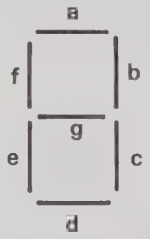


Figure 5-1. Segment Identification

1. The "a" segments of the digits, and the dB and V annunciators are displayed.
2. The "'b" segments of the digits are displayed.
3. The "c" segments of the digits are displayed.
4. The "d" segments of the digits, and the m (mA) RCL and RMT annunciators are displayed.
5. The "e" segments of the digits, minus sign and the REL, M and Ω annunciators are displayed.
6. The "f" segments of the digits, and the AUTO, BAT, m (mV) and c annunciators are displayed.
7. The "g" segments of the digits, and the AC and k annunciators are displayed.
8. The decimal points, most significant digit and the STO, μ and A annunciators are displayed.

Troubleshooting Test Modes—The troubleshooting mode is designed to switch on various switching FETs, transistors and logic levels to allow signal tracing through the instrument. The first displayed mode will reflect the selected function and range. For example, assume that "0u1" is displayed. The "u" corresponds to the volts function, the "1" corresponds to the 200mV range and the "0" is the test number. The test number can be changed by pressing in the dB button. Table 5-2 lists the test modes for all functions and ranges.

To update the test mode, select the new function and range and hold in the dB button until the function symbol changes.

Troubleshooting consists of selecting the desired test mode and using the data found in Table 5-2 to signal trace the circuit.

NOTES:

1. When a different function or range is selected the dB button must be pressed and held in to update the display with the corresponding test mode.
2. Do not use AUTO when in AC or DC volts.
3. Use AUTO when checking circuitry on the 20MΩ and 200MΩ ranges (Xo6).

Table 5-2. Troubleshooting Modes

Function & Range	Test Mode	AMP Gain (U105*)	Multiplexer FET On	Ohms Range Transistor On	Range Control Logic levels on U114			
					PA0	PA1	PA2	PA3
200MVDC	0u1	X10	Q110		1	1	1	1
	1u1	X10	Q111		1	1	1	1
	2u1	X1	Q113		1	1	1	1
	3u1	X1	Q111		1	1	1	1
2VDC	0u2	X1	Q110		1	1	1	1
	1u2	X1	Q111		1	1	1	1
	2u2	X1	Q113		1	1	1	1
	3u2	X1	Q111		1	1	1	1
20VDC	0u3	X1	Q110		1	0	1	1
	1u3	X1	Q111		1	0	1	1
	2u3	X1	Q113		1	0	1	1
	3u3	X1	Q111		1	0	1	1
200VDC	0u4	X1	Q110		1	0	0	1
	1u4	X1	Q111		1	0	0	1
	2u4	X1	Q113		1	0	0	1
	3u4	X1	Q111		1	0	0	1
1000VDC	0u5	X1	Q110		0	0	1	1
	1u5	X1	Q111		0	0	1	1
	2u5	X1	Q113		0	0	1	1
	3u5	X1	Q111		0	0	1	1
200mVAC	0u1	X10	Q110		1	1	1	1
	1u1	X10	Q111		1	1	1	1
	2u1	X1	Q113		1	1	1	1
	3u1	X1	Q111		1	1	1	1
2VAC	0u2	X10	Q110		1	0	1	1
	1u2	X10	Q111		1	0	1	1
	2u2	X1	Q113		1	0	1	1
	3u2	X1	Q111		1	0	1	1
20VAC	0u3	X10	Q110		1	0	0	1
	1u3	X10	Q111		1	0	0	1
	2u3	X1	Q113		1	0	0	1
	3u3	X1	Q111		1	0	0	1
200VAC	0u4	X10	Q110		1	0	1	1
	1u4	X10	Q111		1	0	1	1
	2u4	X1	Q113		1	0	1	1
	3u4	X1	Q111		1	0	1	1
750VAC	0u5	X10	Q110		0	0	1	1
	1u5	X10	Q111		0	0	1	1
	2u5	X1	Q113		0	0	1	1
	3u5	X1	Q111		0	0	1	1
ACA & DCA ALL Ranges	0A1-0A6	X10	Q110		0	0	0	1
	1A1-1A6	X10	Q111		0	0	0	1
	2A1-2A6	X1	Q113		0	0	0	1
	3A1-3A6	X1	Q111		0	0	0	1

Table 5-2. Troubleshooting Mode (Cont.)

Function & Range	Test Mode	Amp Gain (U105*)	Multiplexer FET On	Ohms Range Transistors On	Range Control Logic levels on U114			
					PA0	PA1	PA2	PA3
200Ω	0o1	X10	Q110	Q104	1	1	1	0
	1o1	X10	Q111	Q104	1	1	1	0
	2o1	X1	Q112	Q104	1	1	1	0
	3o1	X1	Q110	Q104	1	1	1	0
	4o1							
	5o1	X1	Q111	Q104	1	1	1	0
	6o1	X1	Q113	Q104	1	1	1	0
2kΩ	0o2	X1	Q110	Q104	1	1	1	0
	1o2	X1	Q111	Q104	1	1	1	0
	2o2	X1	Q112	Q104	1	1	1	0
	3o2	X1	Q110	Q104	1	1	1	0
	4o2							
	5o2	X1	Q111	Q104	1	1	1	0
	6o2	X1	Q113	Q104	1	1	1	0
20kΩ	0o3	X10	Q110	Q105	0	1	1	1
	1o3	X10	Q111	Q105	0	1	1	1
	2o3	X1	Q112	Q105	0	1	1	1
	3o3	X1	Q110	Q105	0	1	1	1
	4o3							
	5o3	X1	Q111	Q105	0	1	1	1
	6o3	X1	Q113	Q105	0	1	1	1
200kΩ	0o4	X1	Q110	Q105	0	1	1	1
	1o4	X1	Q111	Q105	0	1	1	1
	2o4	X1	Q112	Q105	0	1	1	1
	3o4	X1	Q110	Q105	0	1	1	1
	4o4							
	5o4	X1	Q111	Q105	0	1	1	1
	6o4	X1	Q113	Q105	0	1	1	1
2MΩ	0o5	X10	Q110	Q102	1	0	1	
(MΩ)	1o5	X10	Q111	Q102	1	1	0	1
	2o5	X1	Q113	Q102	1	1	0	1
	3o5	X1	Q110	Q102	1	1	0	1
	4o5							
	5o5	X1	Q111	Q102	1	1	0	1
	6o5	X1	Q113	Q102	1	1	0	1
20 & 200MΩ	0o6	X1	Q110	Q102	1	1	0	1
(Auto)	1o6	X1	Q111	Q102	1	1	0	1
	2o6	X1	Q113	Q102	1	1	0	1
	3o6							
	4o6							
	5o6	X1	Q111	Q102	1	1	0	1
	6o6	X1	Q113	Q102	1	1	0	1

* + 4 to 5V (Logic 1) at pin 9 of U106B selects X10 gain, 0V (Logic 0) at pin 9 of U106B selects the X1 gain.

5.4.3 Power Supply and Battery Pack (Model 1758) Checks

Table 5-3 shows the various checks that can be made to the power supplies within the Models 175 and 1758. In addition to the normal voltage checks, it is a good idea to check the various supplies with an oscilloscope to make sure no noise or ringing is present.

5.4.4 A/D Converter and Display

Make sure the A/D converter and display are operating properly before attempting to troubleshoot the signal conditioning circuits. Check these circuits using the information in Tables 5-4 and 5-5.

5.4.5 Signal Conditioning

These circuits can be checked by using the diagnostic program (troubleshooting modes). See paragraph 5.4.2.

Table 5-3. Power Supply Checks and Battery Pack (Model 1758) Checks

Step	Item/Component	Required Condition	Remarks
1	S102 Line Switch	Set to 115 on 230V as required	S102 externally accessible from rear panel.
2	F102 Line Fuse	Continuity.	
3	Line Cord	Plugged into line receptacle; power on	
4	U116** Input (Vin)	+12V ±10%	+5V regulator input.
5	U116** Output (Vo)	+5V ±5%	+5V regulator output.
6	U117 Input (Vin)	-20V to -14V	Negative supply input.
7	U117 Output (Vo)	-10V ±10%	Negative supply output.
8	VR101	-6.25V to -6.45V	Reference zener diode.
9	U103 pin 6	-7V ±5%	Low noise negative supply.
10*	Q101 base	0.6V while charging (power switch off)	Current sink.
11*		Line cord disconnected, battery pack charged, power switch on.	
12*	U101 pin 8	>8.8V	Voltage inverter.
13*	U102 pin 7	+5V with batteries charged	Voltage comparator.

*Checks for the Model 1758

**If U116 is replaced, be sure that the device is properly seated on the mother board so that it will not touch the IEEE board (if installed).

Table 5-4. A/D Converter Checks

Step	Item/Component	Required Condition	Remarks
1		Turn on power; select 2V DC range. Short input.	
2	U123, pin 38	3.2768MHz Clock	Crystal (Y101)
3	U122, pin 10	655.36kHz Clock	Address strobe
4	U122, pin 6	81.92kHz Clock	Synchronous clock for A/D
5	U122, pin 5	40. 96kHz Clock	Synchronous clock for A/D
6	U122, pin 7	163.84kHz Clock	Synchronous clock for A/D
7	U122, pin 12	1.28kHz Clock	Integrator timebase and real time interrupt.
8	U119B, pin 6	+5V to ≈0V pulse train, 3μsec duration every 22μsec	Charge balance synchronization signal.
9	U104, pin 6	Integrator Ramp	
10	U108, pin 6	≈ 1.5V	Comparator Reference
11	U108B, pin 7	Variable pulse train 0V to +5V.	Comparator Output
12	U121A, pin 6	Variable pulse train, 0V to +5V.	Reference current generator.
13	U107A, pin 15	Variable pulse train, 0V to +5V.	
14	U107A, pin 10	≈ 5msec positive going pulses.	Control line for charge balance/single slope.
15	U121B, pin 9	100msec positive going pulse.	Control line for integrator

Table 5-5. Display Board Checks

Step	Item/Component	Required Conditions	Remarks
1		Turn on power; select the 2VDC range.	
2	P1006, pin 5	+3.33V	Vlcd1
3	P1006, pin 6	+1.66V	Vlcd2
4	P1006, pin 7	+5V ±5%	Power to display
5	P1006, pin 2	81.92kHz	clock.
6	P1006, pin 1	0V to +5V Pulses	Data From μp
7	P1006, pin 12	0V to +5V Pulses	Data From μp
8	P1006, pin 13	0V to +5V Pulses	Data From μp
9	P1006, pin 14	+5V to 0V Pulses	Data From μp
10	LCD	Check that LCD is positioned properly.	
11	Connector (P1006)	Check that connector is not reversed. If reversed, display test will run, then display will blank.	
12	Strip Connectors	Check that they are positioned properly.	

5.5 LINE FUSE REPLACEMENT

The line fuse is located internally in the Model 175. For exact fuse location, refer to Figure 6.1. To replace the fuse proceed as follows:

WARNING

Disconnect the line cord and all other sources before removing the top cover.

1. Remove the top cover as explained in paragraph 5.2.
2. If the Model 1753 IEEE-488 interface is installed it must be removed to gain access to the fuse. The IEEE board is secured to the mother board by a support post at the rear, and a connector on the left side. To remove, lift board up until it disenages from the connector and support post.
3. Replace the blown fuse with the following type: 1/8A, 250V, 3AG, Slo-Blo (Keithley P/N-FU-20).

CAUTION

Do not use a fuse with a rating higher than specified or instrument damage may occur. If the instrument persistently blows fuses, a problem may exist within the instrument. If so, the problem must be rectified before continuing operation.

4. If the IEEE interface was installed, reinstall by reversing the procedure in step 2.
5. Reinstall the top cover as explained in paragraph 5.2.

5.6 SPECIAL HANDLING OF STATIC SENSITIVE DEVICES

CMOS devices are designed to operate at very high impedance levels for low power consumption. As a result, any normal static charge that builds up on your person or clothing may be sufficient to destroy these devices if they are not handled properly. Table 5-6 lists the static sensitive devices in the Model 175. when handling these devices, use the following precautions to avoid damaging them.

1. The ICs listed in Table 5-6 should be transported and handled only in containers specially designed to prevent static build-up. Typically, these parts will be received in static-protected containers until ready for installation.
2. Remove the devices from their protective containers only at a properly grounded work station. Also ground yourself with a suitable wriststrap.
3. Handle the devices only by the body; do not touch the pins.
4. Any printed circuit board into which the device is to be inserted must also be grounded to the bench or table.
5. Use only antistatic type solder suckers.
6. Use only grounded soldering irons.

Table 5-6. Static Sensitive Devices

Schematic Designation	Keithley Part No.
U106, U107, U109	IC-283
U111	IC-354
U112	IC-351
U113	LSI-53
U114	LSI-61
U115	LSI-52
U118	IC-143
U119	IC-341
U120	IC-338
U121	IC-337
U122	IC-348
U123	LSI-60
U101*	IC-340

*Part of Model 1758

5.7 FRONT PANEL CALIBRATION

Calibration should be performed every 12 months, or if the performance verification procedures in Section 3 show that the Model 175 is out of specification. If any of the calibration procedures in this section cannot be performed properly, refer to the troubleshooting information in this section. If the problem persists, contact your Keithley representative or the factory for further information.

The entire calibration procedure may be performed without having to make any internal adjustments if frequency compensation (see paragraph 5.7.6) has been verified. It is suggested that the 2V, 20V and 200V ranges at 10kHz be checked (Section 3 Performance Verification) before proceeding.

5.7.1 Recommended Calibration Equipment

Calibration can be performed using the Fluke Model 5101B Calibrator. Alternate test equipment may be used as long as the equipment's accuracy is at least as good as the specifications listed in Table 5-7.

5.7.2 Calibration Jumper

The Model 175 is shipped with its internal calibration jumper in a disabling position. In this position, calibration cannot be done. The jumper must be placed in its enabling position to allow calibration. Proceed as follows:

WARNING

Disconnect the line cord and test leads from the terminals of the Model 175 before removing the top cover.

1. Remove the top cover as explained in paragraph 5.2.
2. The calibration jumper is located in the middle of the mother board right behind the shield. Move the calibration jumper from position A to position B as shown in Figure 5-2.
3. Replace the top cover; plug the line cord back in and turn the instrument on.

5.7.3 Environmental Conditions

Calibration should be performed under laboratory conditions having an ambient temperature of 23 ±3 °C and a relative humidity of less than 70%. With the instrument on, allow it to warm up for one hour. If the instrument has been subjected to temperatures outside this range, or to higher humidity, allow at least one additional hour for the instrument to stabilize before beginning the calibration procedure.

WARNING

Some procedures require the use of high voltage. Take care to prevent contact with live circuits which could cause electrical shock resulting in injury or death.

NOTE

Calibration can be stopped at any time and only selected ranges can be calibrated if needed.

5.7.4 DC Voltage Calibration

Select 200mV DC and connect the calibration source to the VOLTS and COM terminals of the Model 175.

1. Press in the REL and dB pushbuttons simultaneously until the message "CAL" is displayed. Release the buttons. The unit is now in the calibration mode as indicated by the "C" annunciator.
2. Select the 200mV range and press the REL button (REL on).
3. Set the voltage calibrator to output +190.000mV.
4. Adjust the display to read 190.00mV with the use of the STO/CLR and RCL buttons. The STO/CLR button increments the displayed reading and the RCL button decrements the displayed reading.
5. Select the next range (2V) and set the voltage calibration to output +1.90000V.
6. Repeat step 4 to read 1.9000V.
7. Repeat the above procedure for the remaining DC voltage ranges listed in Table 5-8.

Table 5-7. Recommended Calibration Equipment

Description	Specifications	Manufacturer and Model
DC Voltage Calibrator	200mV, 2V, 20V, 200V, 1100V ranges ±0.005% accuracy.	Fluke 5101B
AC Voltage Calibrator	200mV, 2V, 20V, 200V, 1100V ranges ±0.05% accuracy.	Fluke 5101B
Resistance Calibrator	100Ω, 1kΩ, 10kΩ, 100kΩ ranges ±0.005%. 1MΩ range ±0.01% 10MΩ range ±0.05%	Fluke 5101B

Table 5-8. DC Voltage Calibration

175 Range	Calibrator Voltage	175 Reading
200MV	190.000mV	190.00mV
2V	1.90000V	1.9000V
20V	19.0000V	19.000V
200V	190.000V	190.00V
1000V	1000.00V	1000.0V

5.7.5 AC Voltage Calibration

With the Model 175 still in the calibration mode ("C" annunciator on), select the AC volts function and connect the calibration source to the VOLTS and COM terminals of the Model 175. Steps 1 through 6 must be performed in the exact sequence listed.

1. Select the 200mV range and set the calibrator to output 190.000mV @ 200Hz.
2. Adjust the display using the STO/CLR and RCL buttons to read 190.00mV AC.
3. Press the dB button and verify that the dB annunciator is on.
4. Set the calibrator to output 19.0000mV @ 200Hz.
5. Adjust the display to read 19.00mV.
6. Press the REL button and verify that the dB annunciator is off.
7. Repeat only steps 1 and 2 for the remaining ranges using Table 5-9 as a guide.

5.7.6 Resistance Calibration

With the Model 175 still in the calibration mode ("C annunciator on), select the Ω function and connect the test leads to the OHMS and COM terminals of the Model 175. Table 5-10 summarizes the procedure.

1. With the test leads connected to the Model 175, short the other ends together.
2. Select the 200Ω range and press the REL button on the Model 175. The REL annunciator will turn on and the display will zero (test lead compensation).
3. Disconnect the short and connect the test leads to the calibrator.
4. Set the calibrator to output 100Ω and adjust the display, using the STO/CLR and RCL buttons for a reading of 100.00Ω.
5. Press the REL button and note that the REL annunciator turns off.
6. Select the 2kΩ range and again short the test leads together.
7. Press the REL button. The REL annunciator will turn on and the display will zero.
8. Reconnect the test leads, set the calibrator to output 1kΩ and adjust the Model 175 for a reading of 1.0000kΩ.
9. Press the REL button to turn off REL.
10. Select the 20kΩ range and set the calibrator to output 10kΩ. Adjust the Model 175 to read 10.000kΩ.
11. Repeat step 8 for the 200kΩ, 2MΩ and 20MΩ ranges using Table 5-10 as a guide.

5.7.7 Frequency Compensation

Check high frequency (10kHz) AC volts accuracy as explained in section 3, Performance Verification. In the event that frequency compensation must be performed, three internal trimmer capacitors will have to be adjusted. The trimmer capacitors are accessible through the shield (see Figure 6-1). The shield and PC board must be secured to the bottom cover to prevent movement. This assembly can be secured with two screws and nuts in place of the top cover. When making adjustments use a flat bladed, insulated calibration tool. Proceed as follows:

1. Set the Model 175 for 200VAC and set the calibrator to output 100.000V @ 10kHz.
2. Adjust C101 for a reading of 100.00 ±3 counts.
3. Select the 2V range and set the calibrator to output 1.00000V @ 10kHz.
4. Adjust C104 for a reading of 1.0000 ±8 counts.
5. Repeat steps 1 and 2.
6. Select the 20V range and set the calibrator to output 10.0000V @ 10kHz.
7. Adjust C107 for a reading of 10.000 ±8 counts.

Table 5-9. AC Voltage Calibration

175 Range	Calibrator Voltage	Calibrator Frequency	175 Reading
200mV	190.000mV	200Hz	190.00mV
200mV*	19.0000mV	200Hz	19.00mV
2V	1.90000V	200Hz	1.9000V
20V	19.0000V	200Hz	19.000V
200V	190.000V	200Hz	190.00V
750V	750.00V	400Hz	750.0V

*dB annunciator must be on (indicated two-point calibration).

Table 5-10. Resistance Calibration

175 Range	REL*	Calibration Resistance	175 Reading
200Ω	on	100Ω	100.00Ω
2kΩ	on	1kΩ	1.0000kΩ
20kΩ	off	10kΩ	10.000kΩ
200kΩ	off	100kΩ	100.00kΩ
2MΩ	off	1MΩ	1.0000MΩ
20MΩ	off	10MΩ	10.000MΩ

*REL is used to compensate for test lead resistance on the 200Ω and 2kΩ ranges.

5.7.8 Calibration Storage

To store the calibration constants, simultaneously press the REL and dB button until the message STOR is displayed. If the new calibration constants are not stored, they will be lost when the unit is turned off. If it is desired to disable front panel calibration place the calibration jumper in the appropriate position (see Figure 5-2).

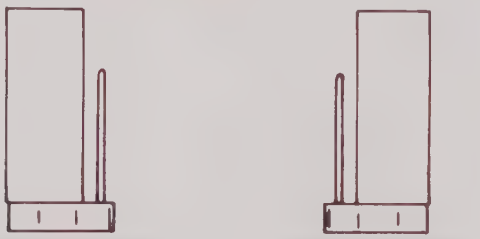


Figure 5-2. Calibration Jumper

5.8 CALIBRATION OVER IEEE-488 BUS

The Model 175, with the Model 1753 installed, can be calibrated over the IEEE-488 bus with the use of a programmable calibrator and a controller.

The following program can be used to calibrate the Model 175 over the IEEE-488 bus. Use the equipment listed below:

1. Model 1753 IEEE-488 Interface.
2. Fluke Model 5100 Series Calibrator with Model 5100A-05 IEEE Interface.
3. Hewlett Packard Model HP-85 Computer with the following:
   A. Model HP 82937A HP-IB Interface
   B. Model HP 82936A ROM Drawer.
   C. I/O ROM (0085-15003)

Detailed operating instructions for the Model 1753 can be found in the Model 1753 Instruction Manual.

Programming Example—Use the following procedure, along with the equipment listed previously, to calibrate the Model 175 over the IEEE-488 bus.

1. Place the calibration jumper in the Model 175 to the calibration enable position (see paragraph 5.7.3).
2. Configure the Model 175/1753, HP-85 and the Fluke Model 5100 Series Calibrator as a system by connecting the instruments together with IEEE cables.
3. Set the primary address of the Model 175/1753 to (11000) 24. Set the Model 5100 Series Calibrator to 17 (10001).
4. Turn the instruments on and allow a one hour warm up.
5. Type the following program into the HP-85.
6. After step 5 is complete check the program to make sure there are no mistakes. If the program has even a small mistake it will not operate as intended.
7. Connect the output of the Model 5100 Series Calibrator to the input terminals of the Model 175.
8. Press the RUN key on the HP-85 to initiate the program.
9. The program will stop at certain predetermined points to prompt the user to change functions. When the prompt instructions have been completed press CONT to resume the program.

PROGRAM	COMMENTS
`10 REMOTE 724,717`	
`20 CLEAR`	
`30 DISP " "`	
`40 DISP "  THIS PROGRAM RUNS A FULL CALI-BRATION ON  THE MODEL 175 USING THE FLUKE MODEL 5101B"`	
`50 DISP " "`	
`60 DISP "  PRESS CONT TO RESUME PROGRAM"`	
`70 PAUSE`	
`80 CLEAR`	
`90 DISP " "`	
`100 DISP " SELECT THE DCV FUNCTION AND  CONNECT THE CALIBRATION SOURCE"`	DC Volts Calibration
`110 DISP " "`	
`120 DISP " "`	
`130 DISP " PRESS CONT TO RESUME PROGRAM"`	
`140 DISP " "`	
`150 PAUSE`	
`160 OUTPUT 724 ;"R1X"`	Sets 175 to 200mV range.
`170 OUTPUT 717 ;"0V,N"`	Outputs 0V to 175.
`180 WAIT 1000`	
`190 OUTPUT 724 ;"Z1X"`	Turns REL on.
`200 WAIT 1000`	
`210 OUTPUT 717 ;".19V,N"`	Outputs 190mV to 175.
`220 WAIT 5000`	
`230 OUTPUT 724 ;"V.19X"`	Calibrates 200mV range.
`240 WAIT 2000`	
`250 OUTPUT 724 ;"R2X"`	Sets 175 to 2V range.
`260 OUTPUT 717 ;"0V,N"`	Outputs 0V to 175.
`270 WAIT 1000`	
`280 OUTPUT 724 ;"Z1X"`	Turns REL on.
`290 WAIT 1000`	
`300 OUTPUT 717 ;"1.9V,N"`	Outputs 1.9V to 175.
`310 WAIT 5000`	
`320 OUTPUT 724 ;"V1.9X"`	Calibrates 2V range.
`330 WAIT 2000`	
`340 OUTPUT 724 ;"R3X"`	Sets 175 to 20V range.
`350 OUTPUT 717 ;"19V,N"`	Outputs 19V to 175.
`360 WAIT 5000`	
`370 OUTPUT 724 ;"V19X"`	Calibrates 20V range.
`380 WAIT 2000`	
`390 OUTPUT 717 ;"S"`	Sets 5101B to standby.
`400 OUTPUT 724 ;"R4X"`	Sets 175 to 200V range.
`410 CLEAR`	
`420 BEEP 50,1000`	
`430 DISP " "`	
`440 DISP " WARNING! THE FOLLOWING STEPS  USE HIGH VOLTAGE!"`	
`450 DISP " "`	
`460 DISP " PRESS CONT TO RESUME PROGRAM"`	
`470 DISP " "`	
`480 PAUSE`	
`490 DISP " "`	
`500 OUTPUT 717 ;"190V,N"`	Outputs 190V to 175.

PROGRAM	COMMENTS
`510 WAIT 5000`	
`520 OUTPUT 724 ;"V190X"`	Calibrates 200V range.
`530 WAIT 2000`	
`540 OUTPUT 724 ;"R5X"`	Sets 175 to 1000V range.
`550 OUTPUT 717 ;"1000V,N"`	Outputs 1000V to 175.
`560 WAIT 5000`	
`570 OUTPUT 724 ;"V1000X"`	Calibrates 1000V range.
`580 WAIT 2000`	
`590 OUTPUT 717 ;"S"`	Sets 5101B to standby.
`600 CLEAR`	
`610 BEEP 50,1000`	
`620 DISP " "`	
`630 DISP "  DC VOLTS CALIBATION IS NOW COMPLE TE"`	
`640 DISP " "`	
`650 DISP "  SELECT AC VOLTS and ."`	AC Volts Calibration
`660 WAIT 2000`	
`670 DISP " "`	
`680 DISP " PRESS CONT TO RESUME PROGRAM"`	
`690 PAUSE`	
`700 OUTPUT 724 ;"R1X"`	Sets 175 to 200mV range.
`710 OUTPUT 717 ;".19V200H,N"`	Outputs 190mV at 200Hz to 175.
`720 WAIT 5000`	
`730 OUTPUT 724 ;"V .19X"`	Calibrates high end of 200mV range.
`740 WAIT 2000`	
`750 OUTPUT 724 ;"D1X"`	Turns dB annunciator on.
`760 OUTPUT 717 ;"19E-3V200H,N"`	Outputs 19mV at 200Hz to 175.
`770 WAIT 5000`	
`780 OUTPUT 724 ;"V19E-3X"`	Calibrates low end of 200mV range.
`790 WAIT 2000`	
`800 OUTPUT 724 ;"Z0X"`	Turns dB annunciator off.
`810 WAIT 5000`	
`820 OUTPUT 724 ;"R2X"`	Sets 175 to 2V range.
`830 OUTPUT 717 ;"1.9V200H,N"`	Outputs 1.9V at 200Hz to 175.
`940 WAIT 5000`	
`850 OUTPUT 724 ;"V1 9X"`	Calibrates 2V range.
`860 WAIT 2000`	
`870 OUTPUT 724 ;"R3X"`	Sets 175 to 20V range.
`880 OUTPUT 717 ;"19V200H,N"`	Outputs 19V at 200Hz to 175.
`890 WAIT 5000`	
`900 OUTPUT 724 ;"V19X"`	Calibrates 20V range.
`910 WAIT 2000`	
`920 OUTPUT 717 ;"S"`	Sets 5101B to standby.
`930 OUTPUT 724 ;"R4X"`	Sets 175 to 200V range.
`940 CLEAR`	
`950 BEEP 50,1000`	
`960 DISP " "`	
`970 DISP " WARNING! THE NEXT STE PS USE HIGH VOLTA GE!"`	
`980 DISP " "`	
`990 DISP " PRESS CONT TO RESUME PROGRAM"`	
`1000 PAUSE`	
`1010 OUTPUT 717 ;"190V200H,N"`	Outputs 190V at 200Hz to 175.
`1020 WAIT 5000`	
`1030 OUTPUT 724 ;"V190X"`	Calibrates 200V range.

PROGRAM	COMMENTS
`1040 WAIT 2000`	
`1050 OUTPUT 717 ;"S"`	Sets 5101B to standby.
`1060 OUTPUT 724 ;"R5X"`	Sets 175 to 750V range.
`1070 OUTPUT 717 ;"750V400H,N"`	Outputs 750V at 400Hz to 175.
`1080 WAIT 5000`	
`1090 OUTPUT 724 ;"V750X"`	Calibrates 750V range.
`1100 WAIT 2000`	
`1110 OUTPUT 717 ;"S"`	Sets 5101B to standby.
`1120 CLEAR`	
`1130 BEEP 50,1000`	
`1140 DISP " "`	
`1150 DISP "AC VOLTS CALIBRATION IS COMPLETE"`	
`1160 WAIT 2000`	
`1170 DISP " "`	
`1180 DISP "SELECT OHMS and REMEMBER TO RE- LEASE THE AC BUTTON"`	Ohms Calibration
`1190 WAIT 2000`	
`1200 DISP " "`	
`1210 DISP " PRESS CONT TO RESUME PROGRAM"`	
`1220 PAUSE`	
`1230 CLEAR`	
`1240 OUTPUT 724 ;"R1X"`	Sets 175 to 200Ω range.
`1250 FOR H=0 TO 1`	Sets program for one loop.
`1260 GOTO 1270`	
`1270 OUTPUT 717 ;"1Z,N"`	Outputs 1Ω to 175.
`1280 WAIT 5000`	
`1290 ENTER 724 ; D`	Enter displayed reading (D).
`1300 A=D-1`	A = Test lead resistance and cal error.
`1310 OUTPUT 717 ;"100Z,N"`	Output 100Ω to 175.
`1320 WAIT 5000`	
`1330 B=100`	B = 100Ω from 5101B.
`1340 F=B+A`	F = Cal point plus lead resistance and cal error.
`1350 C$="V"&VAL$(F)&"X"`	C$ = Command that calibrates 175 using F.
`1360 OUTPUT 724 ;C$`	Calibrate 200Ω range.
`1370 WAIT 2000`	
`1380 NEXT H`	Loops to line 1080 once.
`1390 OUTPUT 724 ;"R2X"`	Sets 175 to 2kΩ range.
`1400 FOR H=0 TO 1`	Sets program for one loop.
`1410 GOTO 1420`	
`1420 OUTPUT 717 ;"1Z,N"`	Outputs 1Ω to 175.
`1430 WAIT 5000`	
`1440 ENTER 724 ; D`	Enter displayed reading (B).
`1450 A=D-1`	A = Test lead resistance and cal error.
`1460 OUTPUT 717 ;"1E3Z,N"`	Output 1kΩ to 175.
`1470 WAIT 5000`	
`1480 B=1000`	B = 1000Ω from 5101B.
`1490 F=B+A`	F = Cal point plus lead resistance and cal error.
`1500 C$="V"&VAL$(F)&"X"`	C$ = Command that calibrates 175 using F.
`1510 OUTPUT 724 C$`	Calibrates 2kΩ range.
`1520 WAIT 2000`	
`1530 NEXT H`	Loops to line 1330 once.
`1540 OUTPUT 724 ;"R3X"`	Sets 175 to 20kΩ range.
`1550 OUTPUT 717 ;"10E3Z,N"`	Outputs 10kΩ to 175.
`1560 WAIT 5000`	
`1570 OUTPUT 724 ;"V10E3X"`	Calibrates 20kΩ range.
`1580 WAIT 2000`	
`1590 OUTPUT 724 ;"R4X"`	Sets 175 to 200kΩ range.

PROGRAM	COMMENTS
`1600 OUTPUT 717 ;"100E3Z,N"`	Outputs 100kΩ to 175.
`1610 WAIT 5000`	
`1620 OUTPUT 724 ;"V100E3X"`	Calibrates 200kΩ range.
`1630 WAIT 2000`	
`1640 OUTPUT 724 ,"R5X"`	Sets 175 to MΩ ranges.
`1650 OUTPUT 717 ;"1E6Z,N"`	Outputs 1MΩ to 175.
`1660 WAIT 5000`	
`1670 OUTPUT 724 ,"V1E6X"`	Calibrates 2MΩ range.
`1680 WAIT 2000`	
`1690 OUTPUT 717 ,"10E6Z,N"`	Outputs 10MΩ to 175.
`1700 WAIT 5000`	
`1710 OUTPUT 724 ;"V10E6X"`	Calibrates 20MΩ range.
`1720 WAIT 2000`	
`1730 BEEP 50,1000`	
`1740 DISP "  CAL POINTS ARE NOW ENTERED"`	
`1750 WAIT 1000`	
`1760 DISP " "`	
`1770 DISP "DO YOU WISH TO STORE CAL POINTS IN NVRAM?"`	
`1780 WAIT 1000`	
`1790 DISP " "`	
`1800 DISP "  IF YES,PRESS Y and END LINE"`	
`1810 DISP "  IF NO,PRESS N and END LINE"`	
`1820 INPUT A$`	
`1830 IF A$="Y" THEN 1850`	
`1840 IF A$="N" THEN 1910`	
`1850 OUTPUT 724 ;"L0X"`	Stores calibration points in NVRAM.
`1860 WAIT 2000`	
`1870 FOR I=1 TO 25`	
`1880 BEEP I*RND+1,50`	
`1890 NEXT I`	
`1900 BEEP 40,3000`	
`1910 DISP "**********"`	
`1920 DISP " THE MODEL 175 CALIBRATION IS NOW COMPLETE "`	
`1930 DISP "**********"`	
`1940 END`	

SECTION 6
REPLACEABLE PARTS

6.1 INTRODUCTION

This section contains replacement parts information, component location drawings and schematic diagrams for the Model 175 and Model 1758.

6.2 REPLACEABLE PARTS

Parts are listed alpha-numerically in order of their circuit designation. Table 6-1 contains a parts list information for the Model 175. Table 6-2 contains a parts list for the display board. Table 6-3 contains a parts list for the Model 1788 Battery Pack. Miscellaneous replaceable parts are not listed in a table can be identified in Figures 6-1 and 6-2. Table 6-4 contains a complement of spare parts that can be ordered to maintain up to 10 Model 175's for approximately one year.

6.3 ORDERING INFORMATION

To place an order, or to obtain information concerning replacement parts, contact your Keithley representative or the factory. See the inside front cover for addresses. When ordering include the following information:

1. Instrument Model Number
2. .Instrument Serial Number
3. Part Description
4. Circuit Description (if applicable)
5. Keithley Part Number

6.4 FACTORY SERVICE

If the instrument is to be returned to the factory for service, please complete the service form which follows this section and return it with the instrument.

6.5 COMPONENT LOCATION DRAWINGS AND SCHEMATIC DIAGRAMS

Figure 6-3—Model 175 Display Board, Dwg. No. 175-110.
Figure 6-4—Model 1758 Battery Pack, Component Location Drawing, Dwg. No. 1758-100.
Figure 6-5—Model 175 Mother Board, Component Location Drawing, Dwg. No. 175-100.
Figure 6-6—Model 175 Mother Board, Schematic Diagram, Dwg. No. 175-106.
Figure 6-7—Model 175 Display Board, Schematic Diagram, Dwg. No. 175-116.
Figure 6-8—Model 1758, Schematic Diagram, Dwg. No. 1758-106.

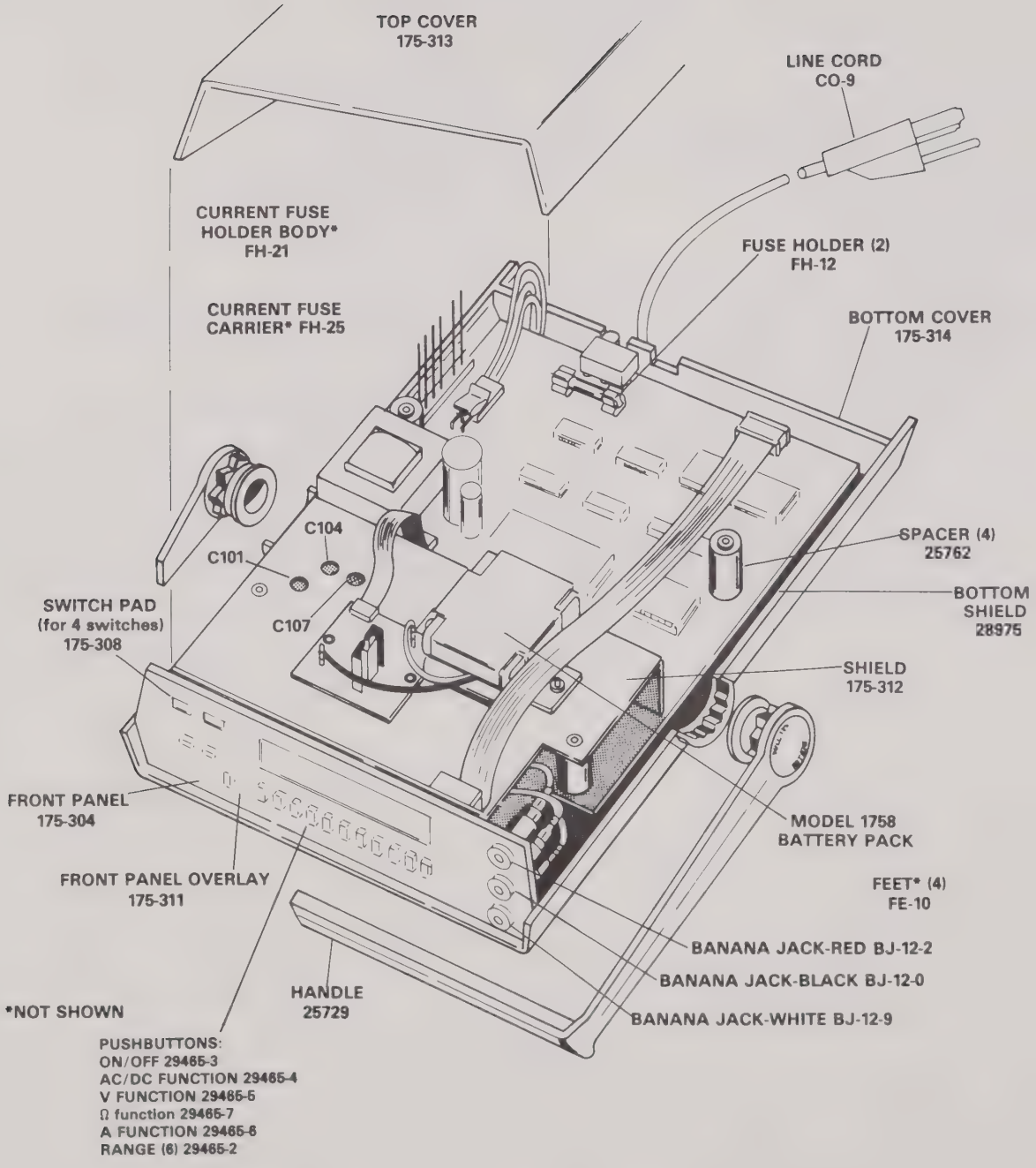


Figure 6-1. Model 175 Miscellaneous Parts

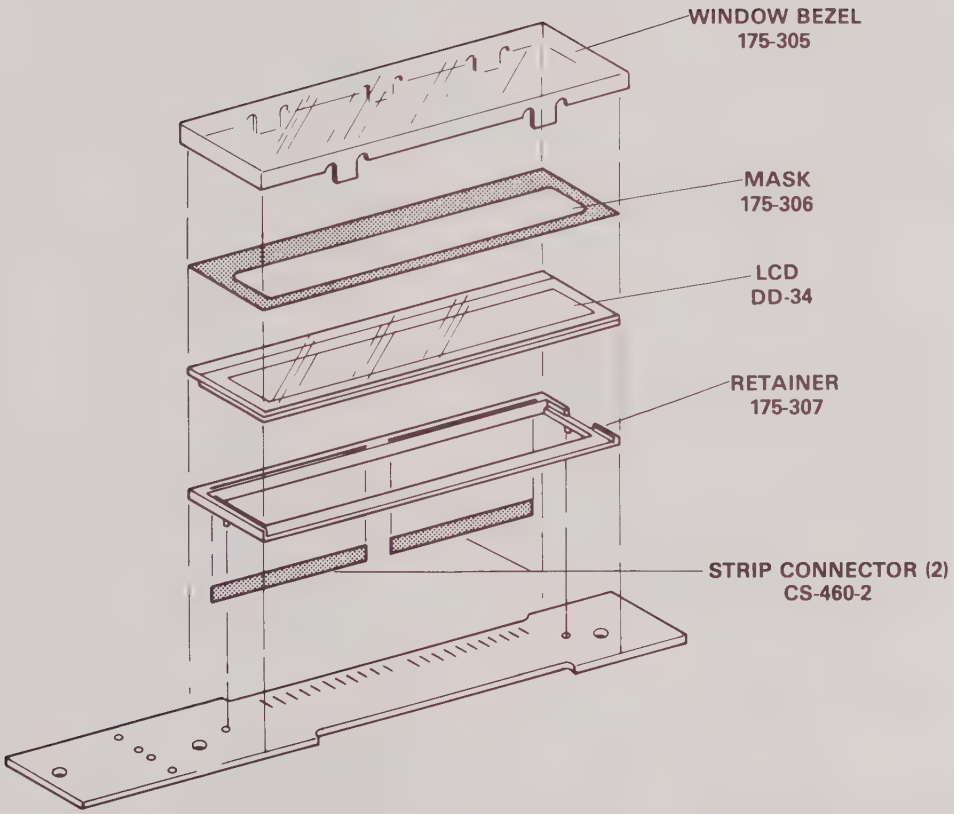


Figure 6-2. Display Assembly

Table 6-1. Mother Board, Parts List

Circuit Desig.	Description	Location Sch*	Location Pcb	Keithley Part No.
C101	Capacitor,	B2-1	C2	C-184
C102	Capacitor, 6.2pF, 1000V, Ceramic Disc	B2-1	C2	C-349-6.2p
C103	Capacitor, 18pF, 50V, 2%, Ceramic	B2-1	C2	C-348-18p
C104	Capacitor, Trimmer, 3-10pF, 500V	B2-1	C2	C-346
C105	Capacitor, 8200pF, 50V, 1%, Ceramic	C2-1	D2	C-347-8200p
C106	Capacitor, .02μF, 500V, 2%, Ceramic Disc	B1-1	C2	C-316-.02
C107	Capacitor, Trimmer, 7-70pF, 500V, Ceramic Disc	C2-1	D2	C-345
C108	Capacitor, 710pF, 50V, 2%, Ceramic	B2-1	D2	C-348-710p
C109	Not Used			
C110	Capacitor, .01μF, 100VDC, 10%, Metal Polypropylene	E3-1	D3	C-306-.01
C111	Capacitor, 1μF, 50VDC, 20%, Metalized Polyester	G1-1	C3	C-350-1
C112	Capacitor, 15μF, 16VDC, 10%, Aluminum Electrolytic	E1-1	C4	C-321-15
C113	Capacitor, 1μF, 50V, Ceramic Film	F1-1	C4	C-237-1
C114	Capacitor, .1μF, 50V, Ceramic Film	E1-1	C4	C-237-.1
C115	Capacitor, 2μF, 1000VDC, 10%, Metal Polyester	F1-1	C4	C-294-2
C116	Capacitor, 10μF, 25V, Aluminum Electrolytic	G2-1	C5	C-314-10
C117	Capacitor, .01μF, 100VDC, 10%, Metal Polypropylene	C1-2	C5	C-306-.01
C118	Capacitor, 1500μF, 25V, Aluminum Electrolytic	F1-2	E2	C-314-1500
C119	Capacitor, 4.7μF, 25V, Aluminum Electrolytic	G1-2	E2	C-314-4.7
C120	Capacitor, 4.7μF, 25V, Aluminum Electrolytic	G1-2	E2	C-314-4.7
C121	Capacitor, 250μF, 25V, Aluminum Electrolytic,	G2-2	E3	C-314-250
C122	Capacitor, 4.7μF, 25V, Aluminum Electrolytic	G1-2	E3	C-314-4.7
C123	Capacitor, 1μF, 50V, Ceramic Film	H3-2	D4	C-237-1
C124	Capacitor, .1μF, 50V, Ceramic Film	F3-2	F4	C-237-.1
C125	Capacitor, 22pF, 1000V, 10%, Ceramic Disk	E6-2	F5	C-64-22p
C126	Capacitor, 22pF, 1000V, 10%, Ceramic Disk	E6-2	F5	C-64-22p
C127	Capacitor, .1μF, 50V, Ceramic Film	B5-2	E5	C-237-.1
C128	Capacitor, .1μF, 50V, Ceramic Film	D6-2	E5	C-237-.1
C129	Capacitor, .1μF, 50V, Ceramic Film	F4-2	F4	C-237-.1
CR101	Diode Silicon, 1N914	A3-1	C4	RF-28
CR102	Rectifier, REC40100	E1-1	B5	RF-36
CR103	Diode, Silicon, IN5400	A4-1	C5	RF-34
CR104	Bridge Rectifier, VM18	F1-2	D3	RF-52
J1006	Socket, 14 pin	G4-2	F5	SO-70
J1009	Connector, Male, 10 pin	G2-2	D3	CS-389-4
K101	Relay, High Voltage, 5V	C1,5-1	C3	RL-82
K102	Relay, Reed	C2,5-1	C3	RL-59
K103	Relay, Reed	C2,5-1	D2	RL-59
P1002	Connector	—	E2	175-316
P1006	Cable Assembly, 14 conductors	—	—	CA-9-3
P1008	Connector	A4-2	F1	175-321
Q101	Transistor, NPN, 2N3904	D2-1	B2	TG-47
Q102	Transistor, NPN, 2N5089	C3-1	C2	TG-62
Q103	Transistor, NPN, 5818	D3-1	D2	TG-138
Q104	Transistor, NPN, 2N5089	D3-1	D2	TG-62
Q105	Transistor, NPN, 2N5089	D3-1	D2	TG-62
Q106	JFET, P-Channel, J270	B2-1	D2	TG-166
Q107	Transistor, NPN, 2N5089	D1-1	C3	TG-62
Q108	Transistor, NPN, 2N5089	D1-1	C4	TG-62

*Zone and page number i.e. B2-1 corresponds to zone B2 of page 1 of schematic

Table 6-1. Mother Board, Parts List (Cont.)

Circuit Desig.	Description	Location Sch*	Location Pcb	Keithley Part No.
Q109	Transistor, NPN, 2N3904	G3-1	D4	TG-47
Q110	JFET, N-Channel, J210	F3-1	D3	TG-167
Q111	JFET, N-Channel, J210	F3-1	D4	TG-167
Q112	JFET, N-Channel, J210	F4-1	D4	TG-167
Q113	JFET, N-Channel, J210	F4-1	D4	TG-167
Q114	FET, N-Channel	B1-2	C5	TG-128
R101	Resistor, 1kΩ, 1%, 1/8W, Metal Film	D2-1	B2	R-177-1k
R102	Resistor, 99kΩ, 1%, 1/8W, Metal Film	D3-1	B2	R-177-99k
R103	Resistor, 220kΩ, 10%, 1W, Composition	B1-1	C2	R-2-220k
R104	Resistor, 402kΩ, 1%, 1/2W, Deposited Carbon	D3-1	D2	R-12-402k
R105	Resistor, 1MΩ, 5%, 1/4W, Composition	E4-1	D2	R-76-1M
R106	Thick Film Resistor Network	SEV	C2	TF-170
R107	Resistor, 390kΩ, 5%, 1/4W, Composition	E3-1	D3	R-76-390k
R108	Resistor, 43kΩ, 5%, 2W, Composition	D1-1	C3	R-320-43k
R109	Thick Film Resistor Network	B3-1	C4	TF-168-1
R110	Resistor, Divider, 0.0999Ω and 0.999Ω, 0.1%, 1W and 2W	B4-1	C4	R-318
R111	Resistor, 10kΩ, 5%, 1/4W, Composition	D1-1	C4	R-76-10k
R112	Resistor, 2.5kΩ, 0.1%, 1/8W	E1-1	C4	R-176-2.5k
R113	Resistor, 1.6kΩ, 0.1%, 1/8W	E1-1	C4	R-176-1.6k
R114	Resistor, 200kΩ, 5%, 1/4W, Composition	F3-1	D4	R-76-200k
R115	Resistor, 100kΩ, 0.1%, 1/8W	F1-1	C4	R-176-100k
R116	Resistor, 64kΩ, 0.1%, 1/8W,	F1-1	C4	R-176-64k
R117	Thick Film Resistor Network	SEV	C4	TF-169
R118	Resistor, 3.3kΩ, 5%, 1/4W, Composition	F4-1	D4	R-76-3.3kΩ
R119	Resistor, 0.01Ω, 0.5%, 1W, Wire Wound	B5-1	C5	R-280-.01
R120	Thick Film Resistor Network	SEV	C5	TF-171
R121	Thick Film Resistor Network	SEV-2	C5	TF-172
R122	Resistor, 47kΩ, 5%, 14W Composition	H4-2	E3	R-76-47k
R123	Resistor, 22Ω, 10%, 2W, Composition	F1-2	E3	R-3-22
R124	Resistor, 8.06kΩ, 1%, 1/8W, Composition	G1-2	E3	R-88-8.06k
R125	Resistor, 1.24kΩ, 1%, 1/8W, Composition	G2-2	E3	R-88-1.24k
R126	Thick Film Resistor, Network	SEV	F4	TF-173
R127	Thick Film, 10MΩ, 1/4W, Composition	F6-2	F5	R-76-10M
R128	Thick Film, 2.2kΩ, 5%, 1/4W, Composition	C2-1	D3	R-76-2.2k
R129	Resistor, 200kΩ, 5%, 1/4W, Composition	F3-1	D3	R-76-200k
R130	Resistor, 200kΩ, 5%, 1/4W, Composition	F4-1	D4	R-76-200k
RT101	Thermister, 4150Ω, 10%, 17.5mA	D3-1	C2	RT-9-1
S101	Switches, pushbuttons	SEV	B2	SW-448
S102	Line Switch	E1-2	F3	SW-318
T101	Transformer, Power (105-125V, 210-250V)	F1-2	D2	TR-201
U101	JFET Op Amp, LF411	E1-1	C4	IC-342
U102	TRMS to DC Converter, 637JD	F1-1	C4	IC-352
U103	Programmable Op Amp, TLC271	F2-1	C5	IC-347
U104	Op Amp, TL061CP	C1-2	C5	IC-227
U105	Programmable Op Amp, TLC271	G3-1	D4	IC-347
U106	Triple 2-Channel Analog Multiplexer, CD4053BC	SEV	D4	IC-283
U107	Triple 2-Channel Analog Multiplexer, CD4053BC	SEV	D5	IC-283
U108	Dual Voltage Comparator, LM393	C2-2	D5	IC-343

Table 6-1. Mother Board, Parts List (Cont.)

Circuit Desig.	Description	Location		Keithley Part No.
		Sch*	Pcb	
U109	Triple 2-Channel Analog Multiplexer, CD4053BC	SEV	D3	IC-283
U110	16 × 16 Bit Serial Nonvolatile Static RAM, X2443P	H4-2	D4	IC-353
U111	Hex Inverter, 74HC04	D5-1	D4	IC-354
U112	Quad 2-Input NAND Gate, 74HC00	C4-1	D4	IC-351
U113	1024 × 4 Bit Static CMOS RAM	A5-2	D5	LSI-62
U114	Peripheral Interface Adapter, 65C21	B3-2	E4	LSI-61
U115	8k × 8 UV Erasable PROM	B5-2	E5	175-800-**
U116	Regulator, +5V, 1A, 7805	G1-2	E3	IC-93
U117	3-Terminal Adjustable Regulator, LM337L	G2-2	E3	IC-345
U118	Triple 3-Input OR Gate, CD4075BE	SEV	E3	IC-143
U119	Triple 3-Input NAND Gate, MM74HC10	SEV	E4	IC-341
U120	Tri-State Octal D Latch, 74HC373	D5-2	E5	IC-338
U121	Dual D Flip-Flop, 74HC74	E2-2	F3	IC-337
U122	12 Stage Binary Counter, 4040B	D3-2	F4	IC-348
U123	CMOS 8-Bit Microprocessor, 146805E2	F3-2	F5	LSI-60
VR101	Diode, Zener, 6.35V, 400mW, 1N4577	F2-1	C5	DZ-58
VR102	Diode, Zener, 12V, 5W, 1N5349	G1-2	E3	DZ-72-1
VR103	Diode, Zener, 5.1V, 400mW, 1N751	G2-1	C5	DZ-59
VR104	Diode, Zener, 12V, 1N963B	H1-2	D3	DZ-54
W101	Calibration Jumper, Connector	H5-2	D4	CS-476
Y101	Crystal, 3.2768MHz	E6-2	F5	CR-21

**Order same software as presently installed. For example, if A1 is the displayed software order 175-800-A1.

Table 6-2. Display Board, Parts List

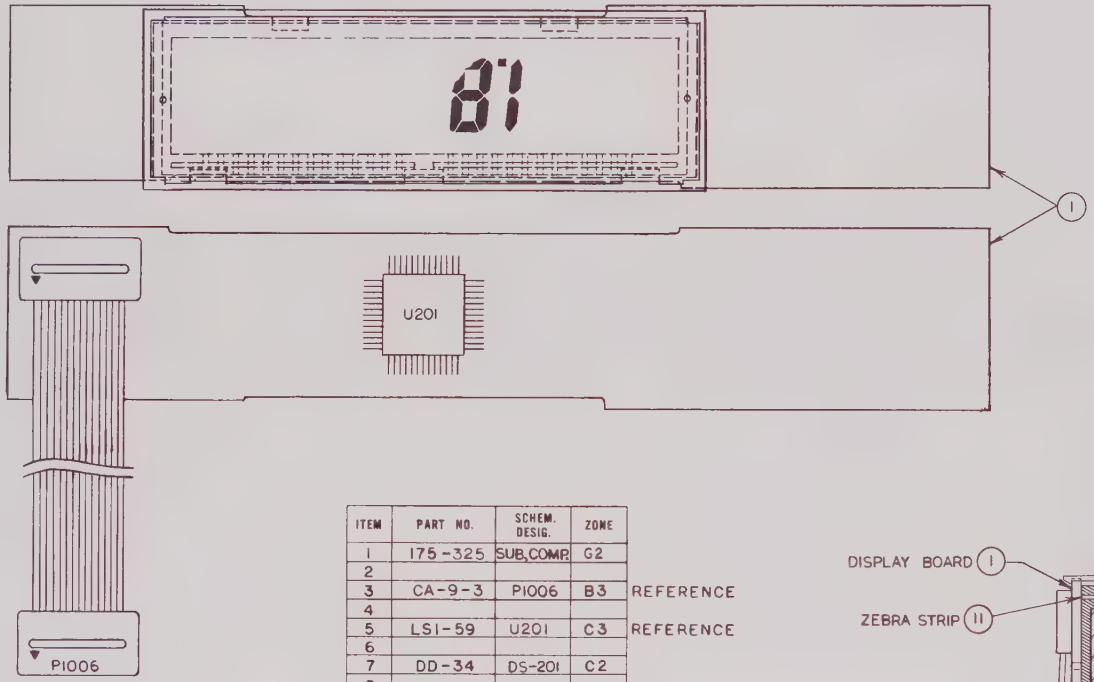
Circuit Desig.	Description	Location Pcb	Location Sch	Keithley Part No.
DS-201	Liquid Crystal Display	D2	D3	DD-34
P1006	Cable Assembly (14 Conductor)	B4	C4	CA-9-3
U201	LCD Controller/Driver	D3	C4	LSI-59

Table 6-3. Model 1758 Battery Pack, Parts List

Circuit Desig.	Description	Location Pcb	Location Sch	Keithley Part No.
BT-101	Battery Assembly, 9.6V sealed rechargeable Ni Cad.	—	B3	BA-38
C101	Capacitor, 250μF, 25VDC, Aluminum Electrolytic	D2	E4	C-314-250
C102	Capacitor, 10μF 25VDC, Aluminum Electrolytic	D3	C4	C-314-10
CR101	Rectifier, Schottky Barrier, 1N5820	D2	D4	RF-53
P1009	Cable Assembly, 10 Conductor	D2	B1	CA-27-1
R101	Resistor, 4.7Ω, 5%, 1/4W, Composition	E2	C3	R-76-4.7
R102	Resistor, 4.7Ω, 5%, 1/4W, Composition	E1	C2	R-76-4.7
R103	Resistor, 30.1kΩ, 1%, 1/8W, Metal Film	E3	E3	R-88-30.1k
R104	Resistor, 39.2kΩ, 1%, 1/8W, Metal Film	E3	E4	R-88-39.2k
R105	Resistor, 1.2MΩ, 5%, 1/4W, Composition	D3	E3	R-76-1.2M
Q101	Transistor, NPN, High Voltage (TIP-49)	D3	C2	TG-137
U101	Voltage Converter, SI7661	D3	D4	IC-340
U102	Voltage Comparator, LM393	D3	E3	IC-343
—	Heat Sink (used on U101)	D3	—	HS-28
	Standoff (Battery Board to Shield)	D3	—	ST-137-8
	Battery Bracket	—	—	1758-305

Table 6-4. Model 175 Spare Parts List

Qty	Keithley Part No.	Circuit Desig.
4	FU-13	F101
2	FU-20	F102
1	RL-82	K101
1	RL-59	K102-K103
5	TG-62	Q102, Q104, Q105, Q107, Q108
1	TG-166	Q106
2	TG-138	Q103
4	TG-167	Q110, Q111, Q112, Q113
1	TG-128	Q114
1	RT-9-1	RT101
1	IC-352	U102
1	IC-347	U103, U105
2	IC-283	U106, U107, U109
1	IC-353	U110
1	IC-354	U111
1	IC-351	U112
1	IC-93	U116
1	IC-345	U117
1	DZ-58	VR101
1	DZ-72-1	VR102



ITEM	PART NO.	SCHEM. DESIG.	ZONE	
1	175-325	SUB,COMP.	G2	
2				
3	CA-9-3	P1006	B3	REFERENCE
4				
5	LS1-59	U201	C3	REFERENCE
6				
7	DD-34	DS-201	C2	
8				
9	175-307	——	C2	
10				
11	CS-460-2	2/U	C2/D2	
12				
13	175-305	——	C2	
14	175-306	——	C2	
15				
16				
17				
18				
19				
20				

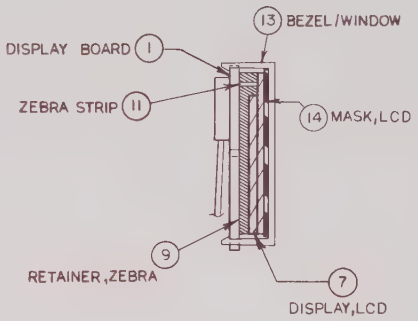


Figure 6-3. Display Board, Component Location Drawing, Dwg. No. 175-110

1758-100 ON

LTR	ECO NO	REVISION	ENG	DATE
A		PRELIMINARY		
B		PRELIMINARY		
C	9450	RELEASED		9/30/83
D	9572	ADDED RT101,		12-20-83

ITEM	PART NO.	SCHEM. DESIG.	ZONE
1	1758-101	STAKING	D2
2			
3	C-314-250	C101	D2
4	C-314-10	C102	D3
5			
6	CA-27-1	P1009	C1
7	IC-340	U101	D3
8	IC-343	U102	D3
9			
10			
11	CS-357	J1011	D3
12	CS-357	J1010	D2
13			
14	TG-137	Q101	D3
15			
16			
D 17	R-1-4.7	R101	D2
18	R-76-4.7	R102	D2
19	R-88-30.1K	R103	D3
20	R-88-39.2K	R104	D3
21	R-76-1.2M	R105	D3
22			
23	RF-53	CR101	D3
24			
D 25	RT-10	RT101	D2
26			
27			
28	HS-28		D3
29			

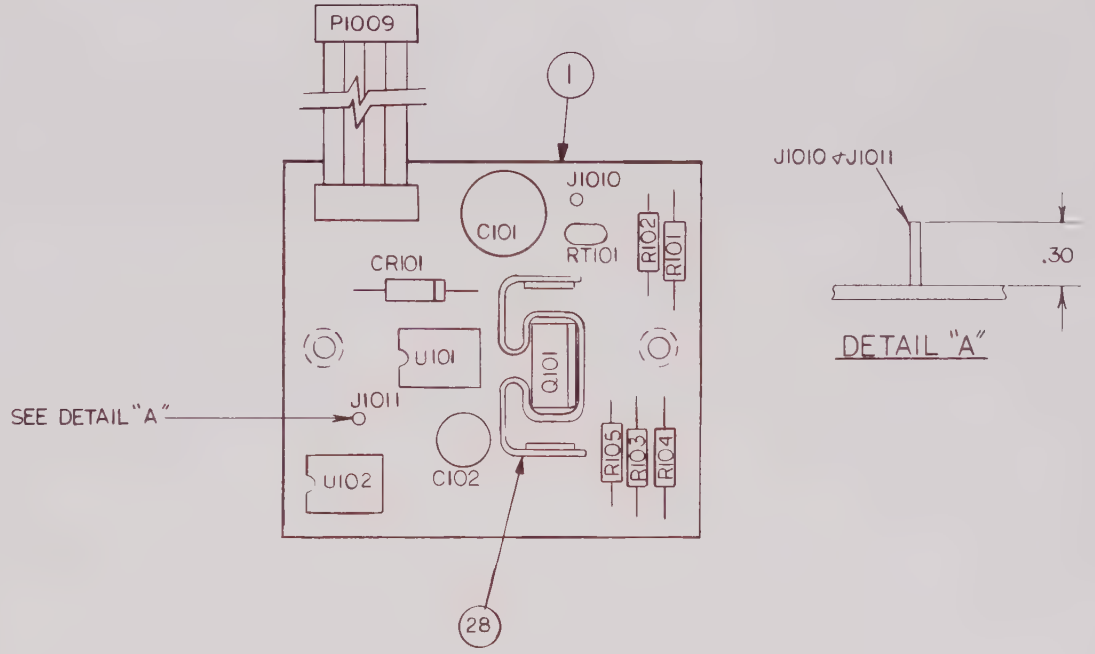
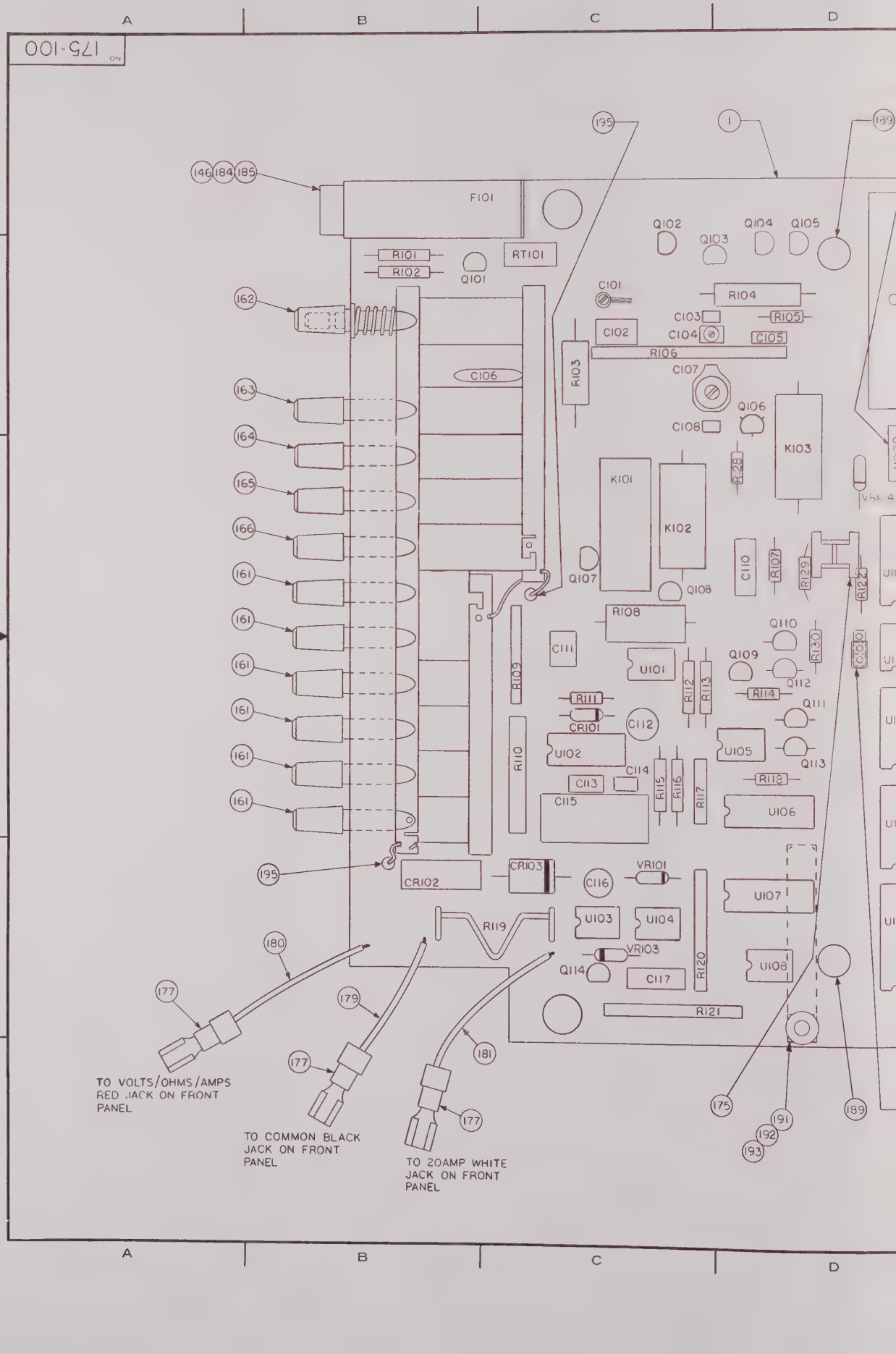


Figure 6-4. Model 1758 Battery Pack, Component Location Drawing, Dwg. No. 1758-100

6-11/6-12


175-100
F101
RT101
R101
R102
Q101
Q102
Q103
Q104
Q105
C101
C102
C103
C104
C105
R104
R105
R106
C107
C108
Q106
K103
K101
K102
Q107
Q108
C110
R107
R129
R122
R108
C111
U101
Q110
Q109
R130
Q112
R114
Q111
R111
CR101
C112
R112
R113
U102
U105
Q113
C114
C113
R115
R116
R117
R118
C115
U106
R110
R103
CR102
CR103
C116
VR101
U107
R119
U103
U104
VR103
Q114
C117
R120
U108
R121
TO VOLTS/OHMS/AMPS RED JACK ON FRONT PANEL
TO COMMON BLACK JACK ON FRONT PANEL
TO 20AMP WHITE JACK ON FRONT PANEL
135
1
139
146
184
185
162
163
164
165
166
161
195
180
177
179
181
175
191
192
193
189

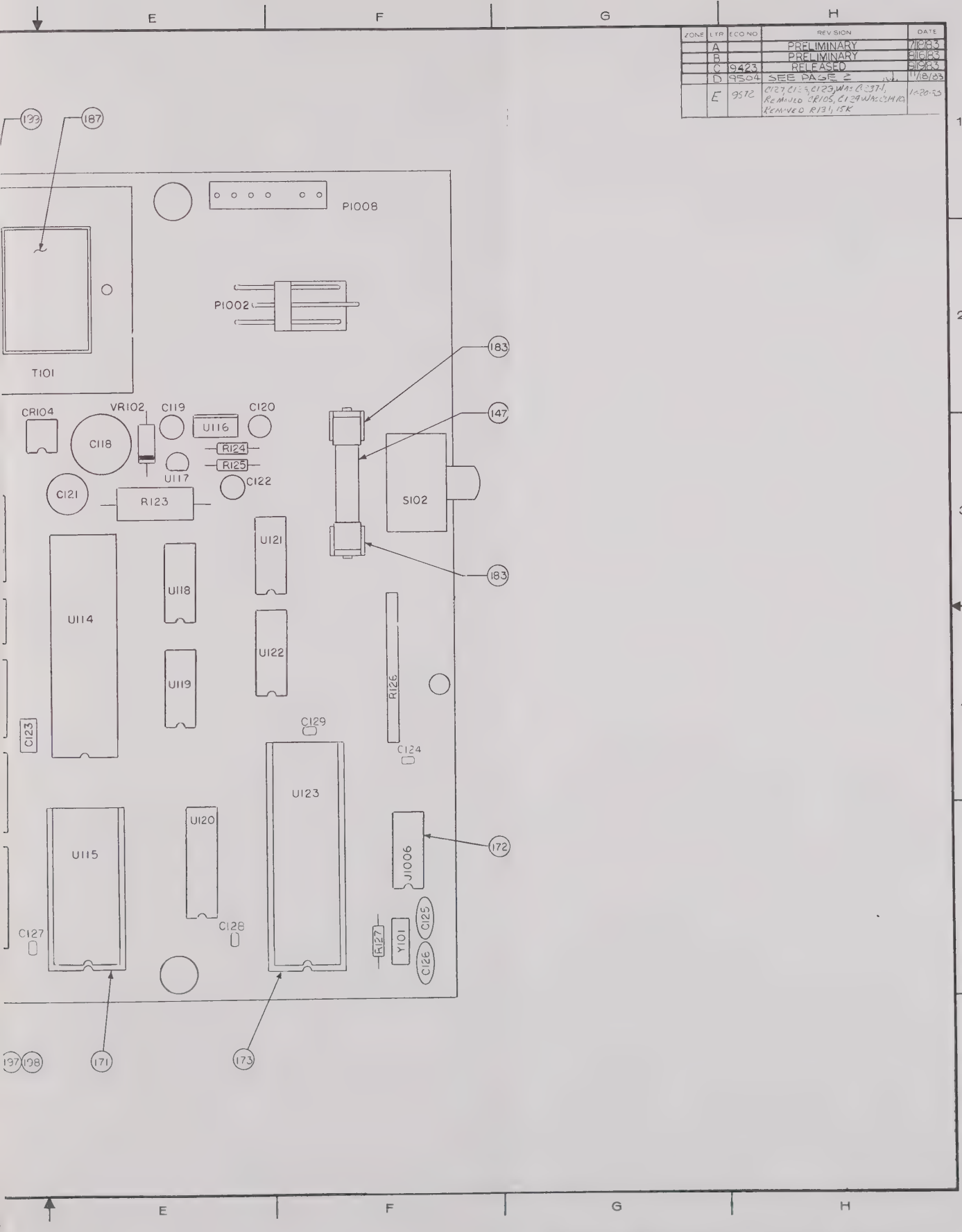


Figure 6-5. Mother Board, Component Location Drawing, Dwg. No. 175-100 (Page 1 of 2)

ITEM	PART NO.	SCHEM. DESIG.	ZONE
1	175-101	STAKING	D1
2			
3			
4			
5	C-184	C101	C2
6	C-349-6.2p	C102	C2
7	C-348-18p	C103	C2
8	C-346	C104	C2
9	C-347-8200p	C105	D2
10	C-316-.02	C106	C2
11	C-345	C107	D2
12	C-348-710p	C108	D2
13			
14	C-306-.01	C110	D3
15	C-350-1	C111	C3
16	C-321-15	C112	C4
17	C-237-1	C113	C4
18	C-237-.1	C114	C4
19	C-294-2	C115	C4
20	C-314-10	C116	C5
21	C-306-.01	C117	C5
22	C-314-1500	C118	E2
23	C-314-4.7	C119	E2
24	"	C120	E2
25	C-314-250	C121	E3
26	C-314-4.7	C122	E3
27	C-237-1	C123	D4
△D 28	C-237-.1	C124	F4
29	C-64-22p	C125	F5
30	"	C126	F5
△E 31	C-237-.1	C127	E5
△E 32	"	C128	E5
△E 33	"	C129	F4
34			
35			
36			
37	R-177-1K	R101	B2
38	R-177-99K	R102	B2
39	R-2-220K	R103	C2
40	R-12-402K	R104	D2

ITEM	PART NO.	SCHEM. DESIG.	ZONE
41	R-76-1M	R105	D2
42	TF-170	R106	C2
43	R-76-390K	R107	D3
44	R-320-43K	R108	C3
45	TF-168-1	R109	C4
46	R-318	R110	C4
47	R-76-10K	R111	C4
48	R-176-2.5K	R112	C4
49	R-176-1.6K	R113	C4
50	R-76-200K	R114	D4
51	R-176-100K	R115	C4
52	R-176-64K	R116	C4
53	TF-169	R117	C4
△D 54	R-76-3.3K	R118	D4
55	R-280-.01	R119	C5
56	TF-171	R120	C5
57	TF-172	R121	C5
58	R-76-47K	R122	E3
59	R-3-22	R123	E3
60	R-88-8.06K	R124	E3
61	R-88-1.24K	R125	E3
62	TF-173	R126	F4
63	R-76-10M	R127	F5
64	R-76-2.2K	R128	D3
△A 65	R-76-200K	R129	D3
△A 66	"	R130	D4
△A 67	R-76-15K	R131	D4
68			
69			
70	RT-9-1	RT101	C2
71			
72			
73			
74	RF-28	CR101	C4
75	RF-36	CR102	B5
76	RF-34	CR103	C5
77	RF-52	CR104	D3
△D 78			
79			
80			

ITEM	P
81	
82	
83	
84	DZ-
85	DZ-
86	DZ-
△A 87	DZ-
88	
89	
90	TG-
91	TG-
△A 92	TG
93	TG-
94	"
95	TG-
96	TG-
97	"
98	TG-
99	TG-
100	"
101	"
102	"
103	TG-
104	
105	
106	
107	
108	
109	
110	IC-
111	IC-
112	IC-
△A 113	IC-
114	IC-
115	IC-
116	"
117	IC-
118	IC-
119	IC-
120	IC-

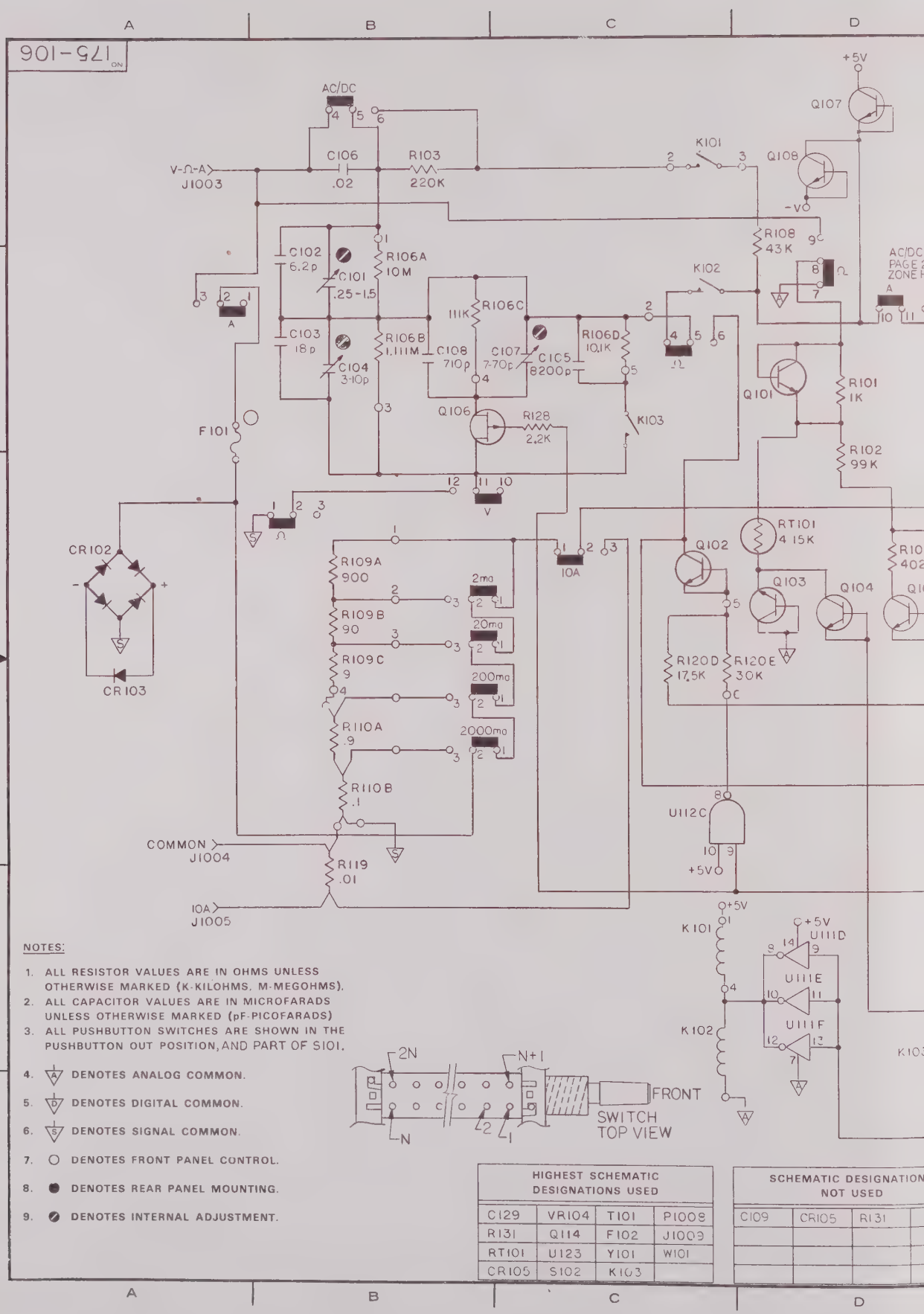
ZONE	LTR	ECO NO.	REVISION	DATE
	A		PRELIMINARY	7/8/83
	B		PRELIMINARY	8/16/83
	C	9423	RELEASED	9/19/83
	D	9504	ADDED ITEMS 31-32-33-C-237-1(C127 C128 C129)ITEM 34 WAS R-76-200K ADDED ITEMS 35 thru R-76-202K(R-29 R-601 ADDED ITEM 87-D2-54(VR104), ITEM 92 WAS TO-92 ITEM 113 WAS IC-350 ITEM 122 WAS LSI-52A ADDED W1-31 TO ITEM 197. ADDED ITEMS -27 R-76-154K 1131, C131 TO MISC. PARTS.	11/18/83
	E	9512	D127, C128, C129, W1, C-237-1, REMOVED J4, M1, C124 W1 C131-10, REMOVED R131, 15K	12/2/83

NO.	SCHEM. DESIG.	ZONE
	VR101	C5
1	VR102	E3
	VR103	C5
	VR104	D3
	Q101	B2
	Q102	C2
	Q103	D2
	Q104	D2
	Q105	D2
	Q106	D2
	Q107	C3
	Q108	C3
	Q109	D4
	Q110	D3
	Q111	D4
	Q112	D4
	Q113	D4
	Q114	C5
	U101	C4
	U102	C4
	U103	C5
	U104	C5
	U105	D4
	U106	D4
	U107	D5
	U108	D5
	U109	D3
	U110	D4
	U111	D4

ITEM	PART NO.	SCHEM. DESIG.	ZONE
121	IC-351	U112	D4
⚠ 122	LSI-62	U113	D5
123	LSI-61	U114	E4
124	LSI-52	U115	E5
125	IC-93	U116	E3
126	IC-345	U117	E3
127	IC-143	U118	E3
128	IC-341	U119	E4
129	IC-338	U120	E5
130	IC-337	U121	F3
131	IC-348	U122	F4
132	LSI-60	U123	F5
133			
134			
135			
136			
137	SW-448	S101	B2-B4
138	SW-318	S102	F3
139			
140			
141			
142	TR-201	T101	D2
143			
144			
145			
146	FU-13	F101	B1
147	FU-20	F102	F3
148			
149			
150			
151	CR-21	Y101	F5
152			
153			
154			
155	RL-82	K101	C3
156	RL-59	K102	C3
157	"	K103	D2
158			
159			
160			

ITEM	PART NO.	SCHEM. DESIG.	ZONE
161	29465-2	6/U	B3-B4
162	29465-3		B2
163	29465-4		B2
164	29465-5		B3
165	29465-6		B3
166	29465-7		B3
167			
168	175-316	P1002	E2
169	175-321	P1008	F1
170			
171	SO-69		E5
172	SO-70	J1006	F5
173	SO-84-40		F5
174			
175	FA-99		D3
176			
177	LU-87	3/U	A6-B6
178			
179	SC-100-0	LENGTH TO SUIT	B5
180	SC-100-2	"	B5
181	SC-100-9	"	B5
182			
183	FH-12	2/U	F2,F3
184	FH-21		B1
185	FH-25		B1
186			
187	MC-221		E2
188			
189	HP-22	2/U	D2,D5
190			
191	26533		F1
192	#6 EXT. L'WASHER		F1
193	6-32×3/16 PHIL PAN HD.		F1
194			
195	J-3	2/U	B5,C1
196			
⚠ 197	CS-476	W101	D4
198	CS-339-3		D4
199	CS-389-4	J1009	D3
200			

Figure 6-5. Mother Board, Component Location Drawing, Dwg. No. 175-100 (Page 2 of 2)



NOTES:

1. ALL RESISTOR VALUES ARE IN OHMS UNLESS OTHERWISE MARKED (K-KILOHMS, M-MEGOHMS).
2. ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS OTHERWISE MARKED (pF-PICOFARADS)
3. ALL PUSHBUTTON SWITCHES ARE SHOWN IN THE PUSHBUTTON OUT POSITION, AND PART OF S101.
4. ▽A DENOTES ANALOG COMMON.
5. ▽D DENOTES DIGITAL COMMON.
6. ▽S DENOTES SIGNAL COMMON.
7. ○ DENOTES FRONT PANEL CONTROL.
8. ● DENOTES REAR PANEL MOUNTING.
9. ⊘ DENOTES INTERNAL ADJUSTMENT.

HIGHEST SCHEMATIC DESIGNATIONS USED			
C129	VR104	T101	P1008
R131	Q114	F102	J1009
RT101	U123	Y101	W101
CR105	S102	K103	

SCHEMATIC DESIGNATION NOT USED			
C109	CR105	R131	

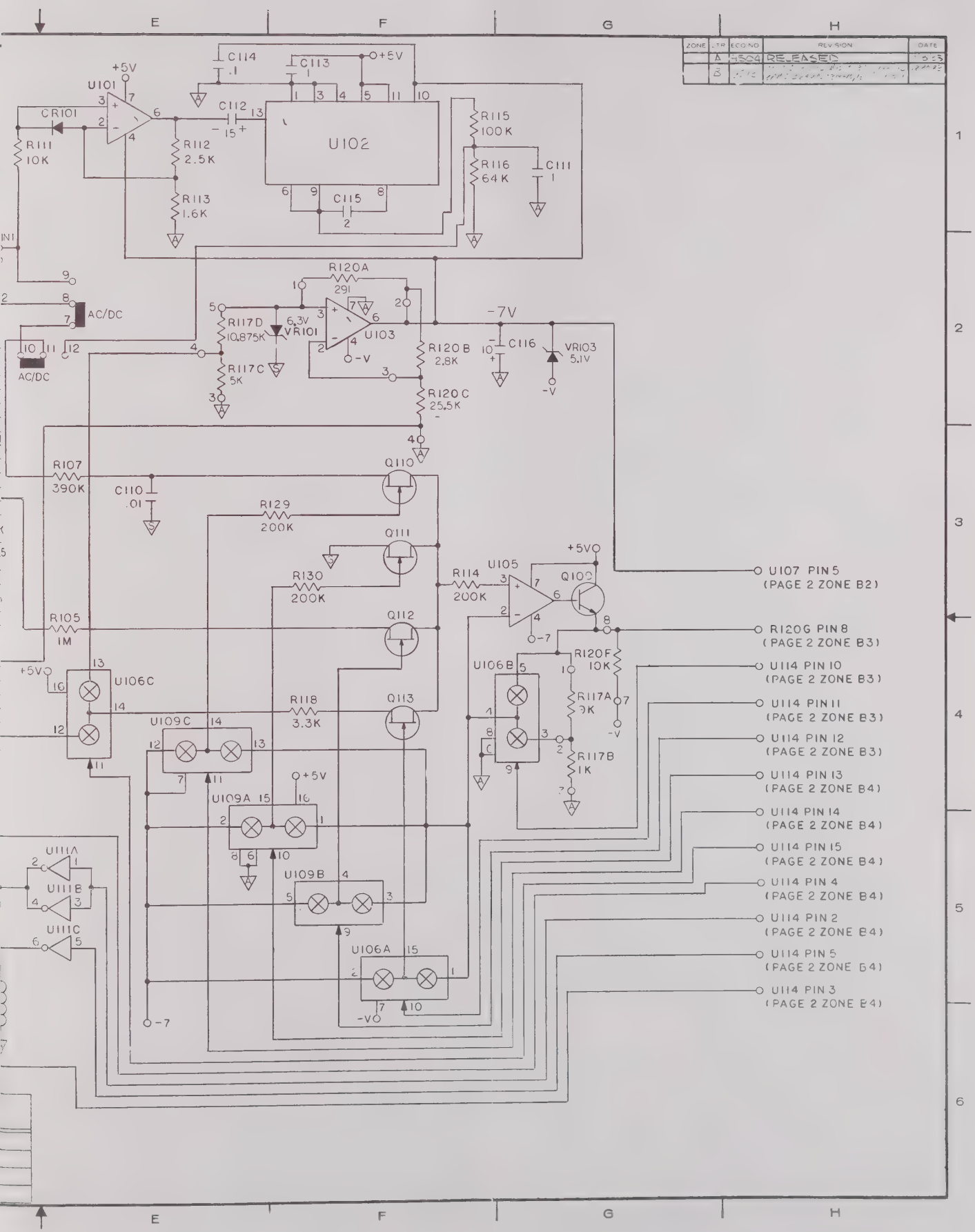
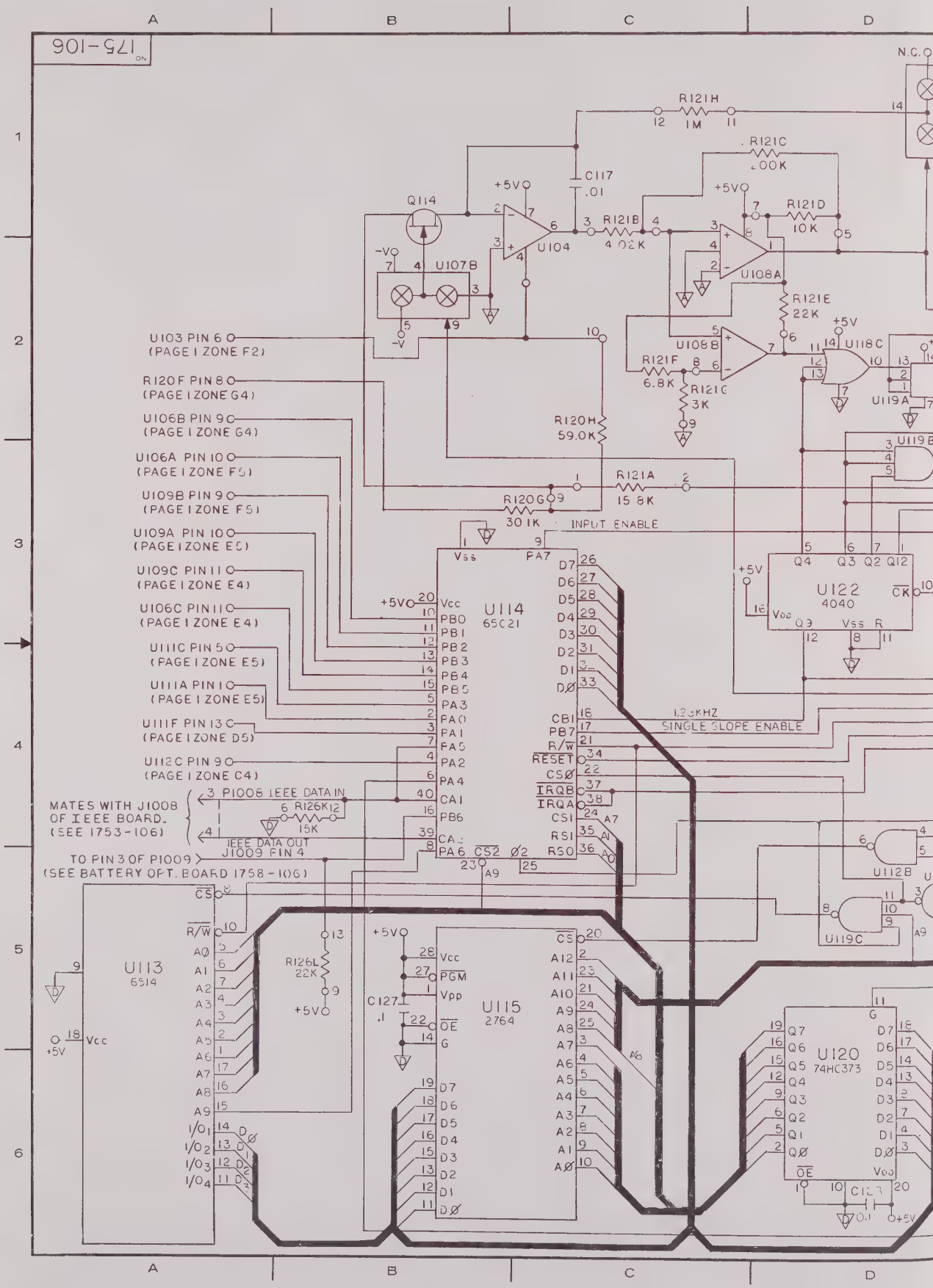


Figure 6-6. Mother Board, Schematic Drawing, Dwg. No. 175-106 (Page 1 of 2)


175-106
R121H
1M
R121C
200K
C117
.01
+5V
Q114
U104
R121B
4.02K
R121D
10K
-V
U107B
U108A
R121E
22K
U108B
R121F
6.8K
R121G
3K
U118C
U119A
U119B
U103 PIN 6
(PAGE 1 ZONE F2)
R120F PIN 8
(PAGE 1 ZONE G4)
U106B PIN 9
(PAGE 1 ZONE G4)
U106A PIN 10
(PAGE 1 ZONE F5)
U109B PIN 9
(PAGE 1 ZONE F5)
U109A PIN 10
(PAGE 1 ZONE E5)
U109C PIN 11
(PAGE 1 ZONE E4)
U106C PIN 11
(PAGE 1 ZONE E4)
U111C PIN 5
(PAGE 1 ZONE E5)
U111A PIN 1
(PAGE 1 ZONE E5)
U111F PIN 13
(PAGE 1 ZONE D5)
U112C PIN 9
(PAGE 1 ZONE C4)
R120H
59.0K
R121A
15.8K
R120G
30.1K
INPUT ENABLE
U114
65C21
Vss
PA7
Vcc
PB0
PB1
PB2
PB3
PB4
PB5
PA3
PA0
PA1
PA5
PA2
PA4
CA1
PB6
CA2
PA6
CS2
Ø2
A9
D7
D6
D5
D4
D3
D2
D1
DØ
CB1
PB7
R/W
RESET
CSØ
IRQB
IRQA
CS1
RS1
RS0
A7
A1
A0
U122
4040
Q4
Q3
Q2
Q12
CK
Vdd
Q3
Vss
R
1.23KHZ
SINGLE SLOPE ENABLE
MATES WITH J1008
OF IEEE BOARD.
(SEE 1753-106)
3 P1008 IEEE DATA IN
6 R126K12
15K
IEEE DATA OUT
J1009 PIN 4
TO PIN 3 OF P1009
(SEE BATTERY OPT. BOARD 1758-106)
U112B
U119C
U113
6514
CS
R/W
A0
A1
A2
A3
A4
A5
A6
A7
A8
A9
I/O1
I/O2
I/O3
I/O4
Vcc
R126L
22K
U115
2764
PGM
Vpp
C127
.1
OE
G
A12
A11
A10
A9
A8
A7
A6
A5
A4
A3
A2
A1
A0
D7
D6
D5
D4
D3
D2
D1
DØ
U120
74HC373
Q7
Q6
Q5
Q4
Q3
Q2
Q1
QØ
OE
Vdd
C123
.01
N.C.

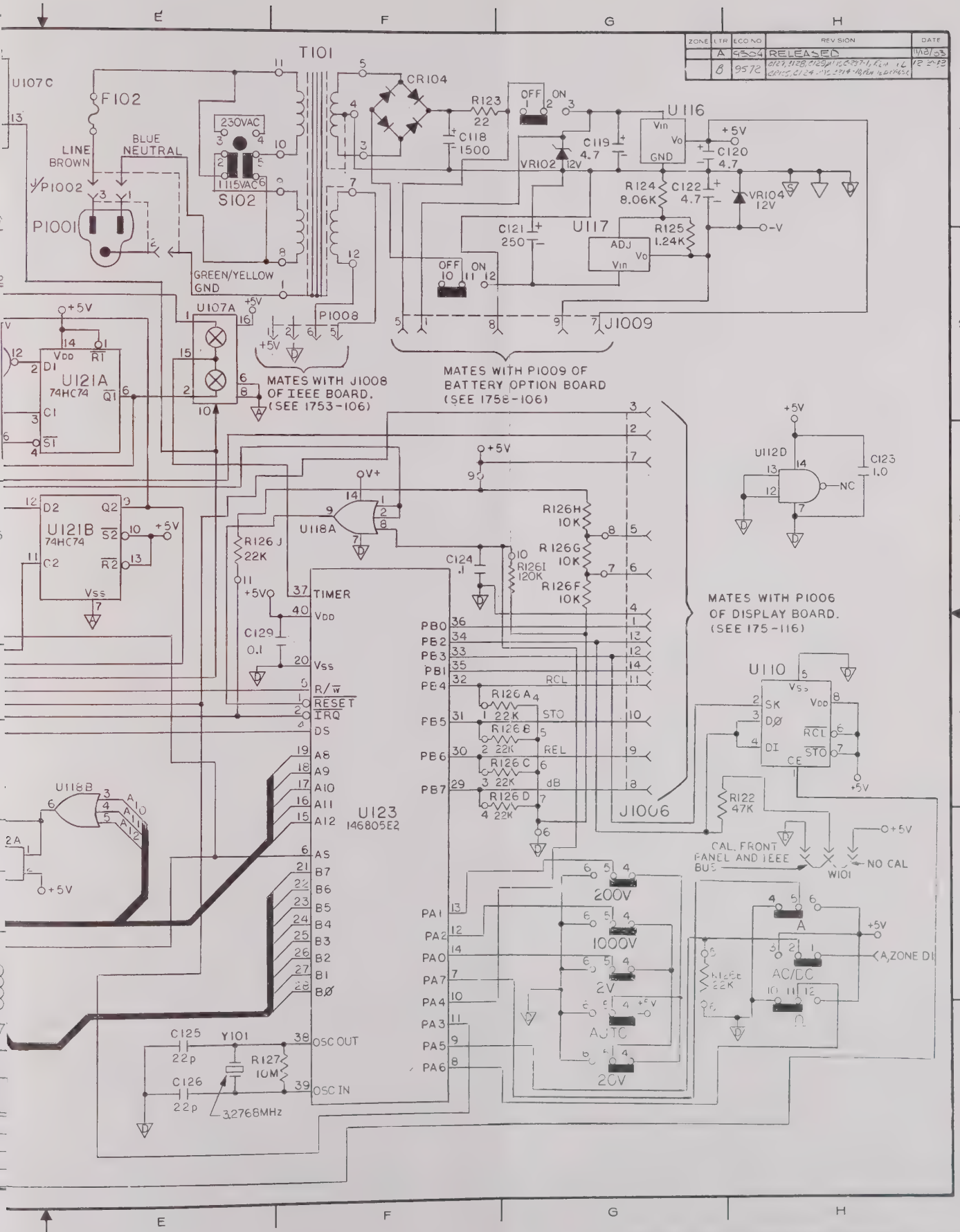


Figure 6-6. Mother Board, Schematic Drawing, Dwg. No. 175-106 (Page 2 of 2)

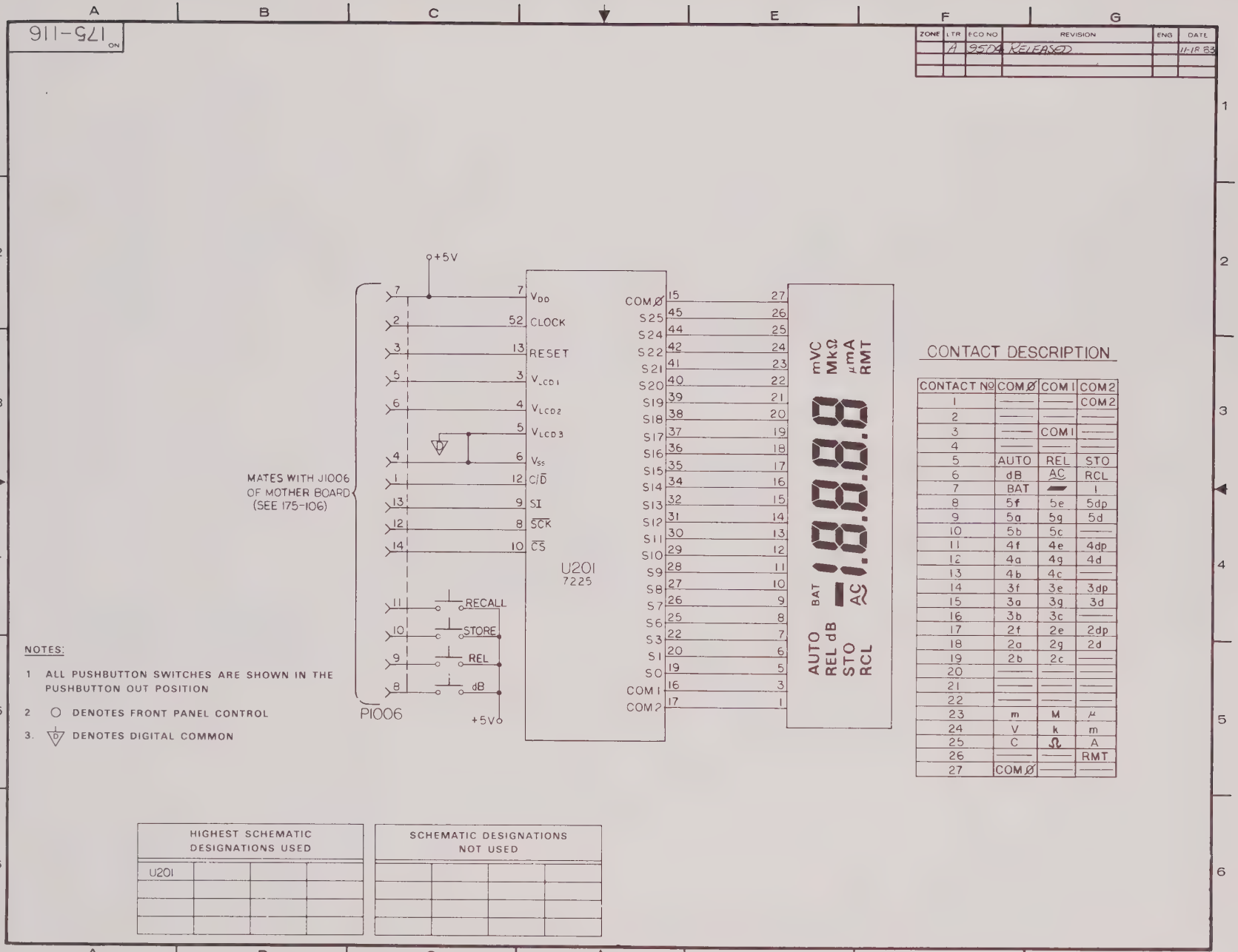

175-116
ZONE | LTR | ECO NO | REVISION | ENG | DATE
A | 9504 | RELEASED | | 11-18-83
+5V
MATES WITH J1006 OF MOTHER BOARD (SEE 175-106)
P1006
U201
7225
RECALL
STORE
REL
dB
AUTO
REL dB
STO
RCL
BAT
AC
mVC
MkΩ
μmA
RMT
NOTES:
1 ALL PUSHBUTTON SWITCHES ARE SHOWN IN THE PUSHBUTTON OUT POSITION
2 ○ DENOTES FRONT PANEL CONTROL
3. ▽ DENOTES DIGITAL COMMON
CONTACT DESCRIPTION
CONTACT NO | COMØ | COM1 | COM2
1 | —— | —— | COM2
2 | —— | —— | ——
3 | —— | COM1 | ——
4 | —— | —— | ——
5 | AUTO | REL | STO
6 | dB | AC | RCL
7 | BAT | ▬ | 1
8 | 5f | 5e | 5dp
9 | 5a | 5g | 5d
10 | 5b | 5c | ——
11 | 4f | 4e | 4dp
12 | 4a | 4g | 4d
13 | 4b | 4c | ——
14 | 3f | 3e | 3dp
15 | 3a | 3g | 3d
16 | 3b | 3c | ——
17 | 2f | 2e | 2dp
18 | 2a | 2g | 2d
19 | 2b | 2c | ——
20 | —— | —— | ——
21 | —— | —— | ——
22 | —— | —— | ——
23 | m | M | μ
24 | V | k | m
25 | C | Ω | A
26 | —— | —— | RMT
27 | COMØ | —— | ——
HIGHEST SCHEMATIC DESIGNATIONS USED
U201
SCHEMATIC DESIGNATIONS NOT USED

Figure 6-7. Display Board, Schematic Diagram, Dwg. No. 175-116

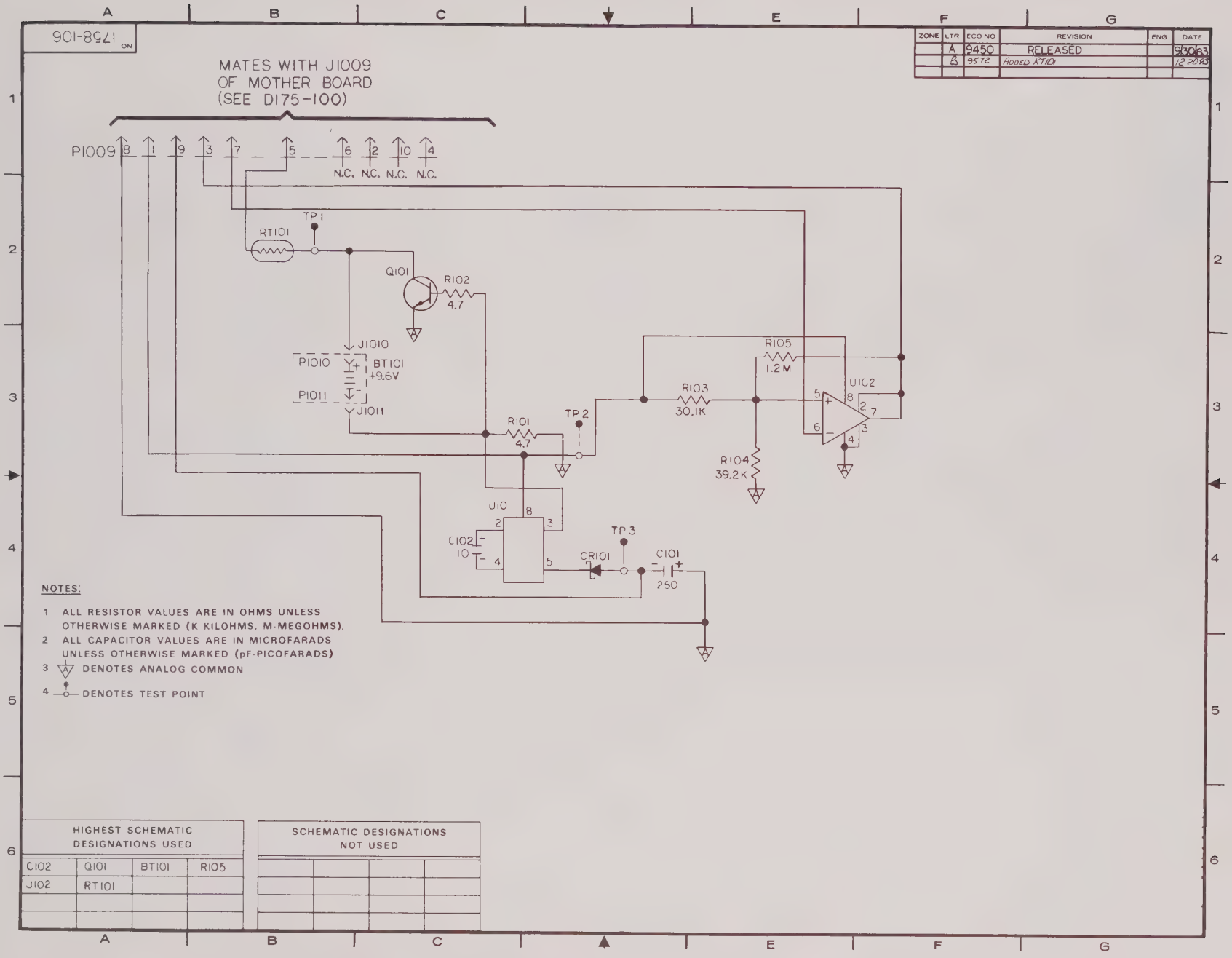


Figure 6-8. Model 1758 Battery Pack, Schematic Drawing, Dwg. No. 1758-106

KEITHLEY

SERVICE FORM

Model No. _____ **Serial No.** _____ **P.O. No.** _____ **Date** _____

Name _____ **Phone** _____

Company _____

Address _____

City _____ **State** _____ **Zip** _____

List all control settings and describe problem. _____

_____

_____

_____ (Attach additional sheets as necessary.)

Show a block diagram of your measurement system including all instruments connected (whether power is turned on or not). Also describe signal source.

Where is the measurement being performed? (factory, controlled laboratory, out-of-doors, etc.) _____

What power line voltage is used? _____ Variation? _____

Frequency? _____ Ambient Temperature? _____ °F.

Variation? _____ °F. Rel. Humidity? _____ Other? _____

Any additional information. (If special modifications have been made by the user, please describe below.)

_____

_____

*Be sure to include your name and phone number on this service form.

KEITHLEY

KEITHLEY INSTRUMENTS, INC.

INSTRUMENT DIVISION / 28775 Aurora Road / Cleveland, Ohio 44139 / U.S.A. / (216) 248-0400 / Telex: 98-5469

WEST GERMANY: Keithley Instruments GmbH / Heiglhofstr. 5 / 8000 München 70 / (089) 710020 / Telex: 52-12160

GREAT BRITAIN: Keithley Instruments, Ltd. / 1, Boulton Road / Reading, Berkshire RG 2 ONL / (0734) 86-12-87/88 / Telex: 84-7047

FRANCE: Keithley Instruments SARL / 2, Bis Rue Léon Blum / B.P. 60 / 91121 Palaiseau Cedex / (6) 011-51-55 / Telex: 600-933

NETHERLANDS: Keithley Instruments BV / Arkelsedijk 4 / Postbus 559 / 4200 AN Gorinchem / (0) 1830-25577 / Telex: 24-684

SWITZERLAND: Keithley Instruments SA / Kriesbachstr. 4 / 8600 Dübendorf / 01/821-94-44 / Telex: 57-536

AUSTRIA: Keithley Instruments Ges.m.b.H. / Döblinger Haupstr. 32 / 1190 Wien / 314 289 / Telex: 13-4500

ITALY: Keithley Instruments, SRL / Viale S. Gimignano 4/A / 20100 Milano, Italy / 4120360